Scientific Water-Survey Report

Date: 27/02/21

Summary

The client commissioned a scientific water survey in the US embassy residential properties. The work entitled a desk study of the hydrogeological and geophysical background followed by ground geophysical surveys.

The geophysical technique employed was electrical resistivity. Analysis of the results enabled the mapping of structures that are important to ground water occurrence and are therefore targets for water borehole drilling.

Objective(s)

The primary objective was to identify geological structures that may control groundwater occurrence and hence identify suitable sites for drilling.

Hydrogeology

The area is dominated by granites of the Harare Greenstone Belt (HGB). These rock types fall under a group of hard crystalline rocks and semi crystalline rocks with minimal porosity and permeability. Groundwater occurrence in general is mainly determined by the availability of **deeply weathered zones, porosity and permeability, and structural conduits i.e. faults, fractures and shear zones**. In this case, where the dominant lithology is mostly granitic, the occurrence of groundwater is mainly targeted in deeply weathered zones, fractured and faulted zone.

Geophysics

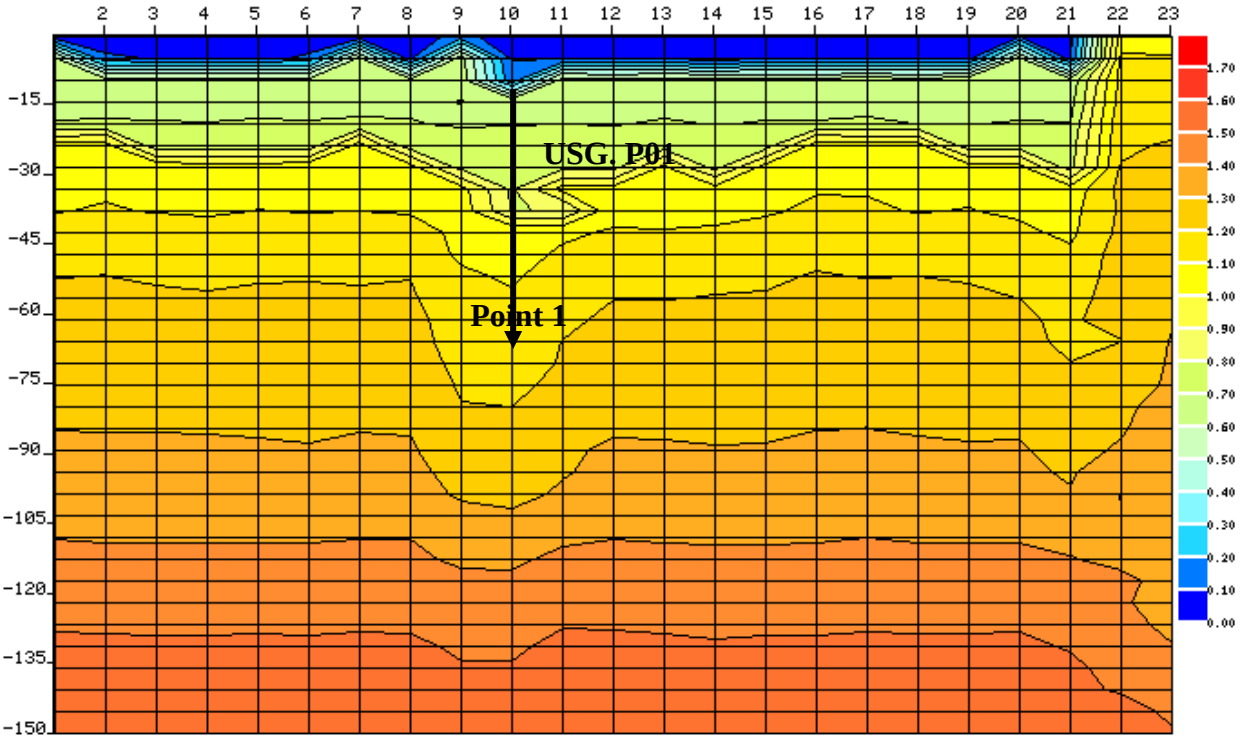
The groundwater exploration exercise employed the Electrical resistivity geophysical method. Geophysical resistivity technique is based on the response of the earth to the flow of electrical current. In this method an electrical current is induced through the ground and two potential electrodes allow to record the resultant potential difference between them, giving a way to measure the electrical impedance of the subsurface material.

In the shallow subsurface, the presence of water controls much of the conductivity variation. Measurement of resistivity (inverse of conductivity) is, in general, a measure of water saturation and connectivity of pore spaces. Therefore, because water has low resistivity, electric current will follow this path of least resistance. Increase in saturation, salinity of the underground water, porosity of rock (water-filled voids) and number of fractures (water-filled) result in low measured resistivity. Increase in compaction of soils or rock units, air in voids increase subsurface resistivity.

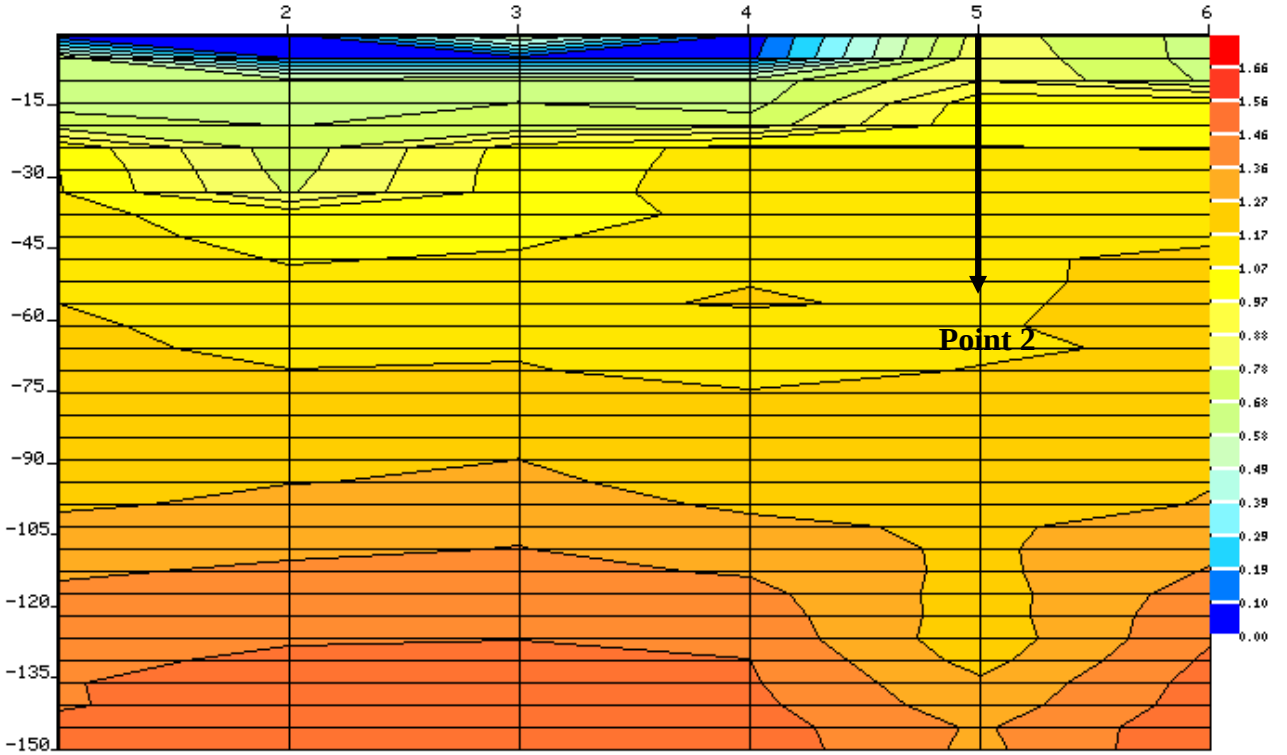
Below are geophysical profile(s), recommendations and discussions which summarizes each line survey carried during the exercise:

Site 1: 2 Wavel Road, Highlands, Harare.

Survey Line 1



Survey Line 2



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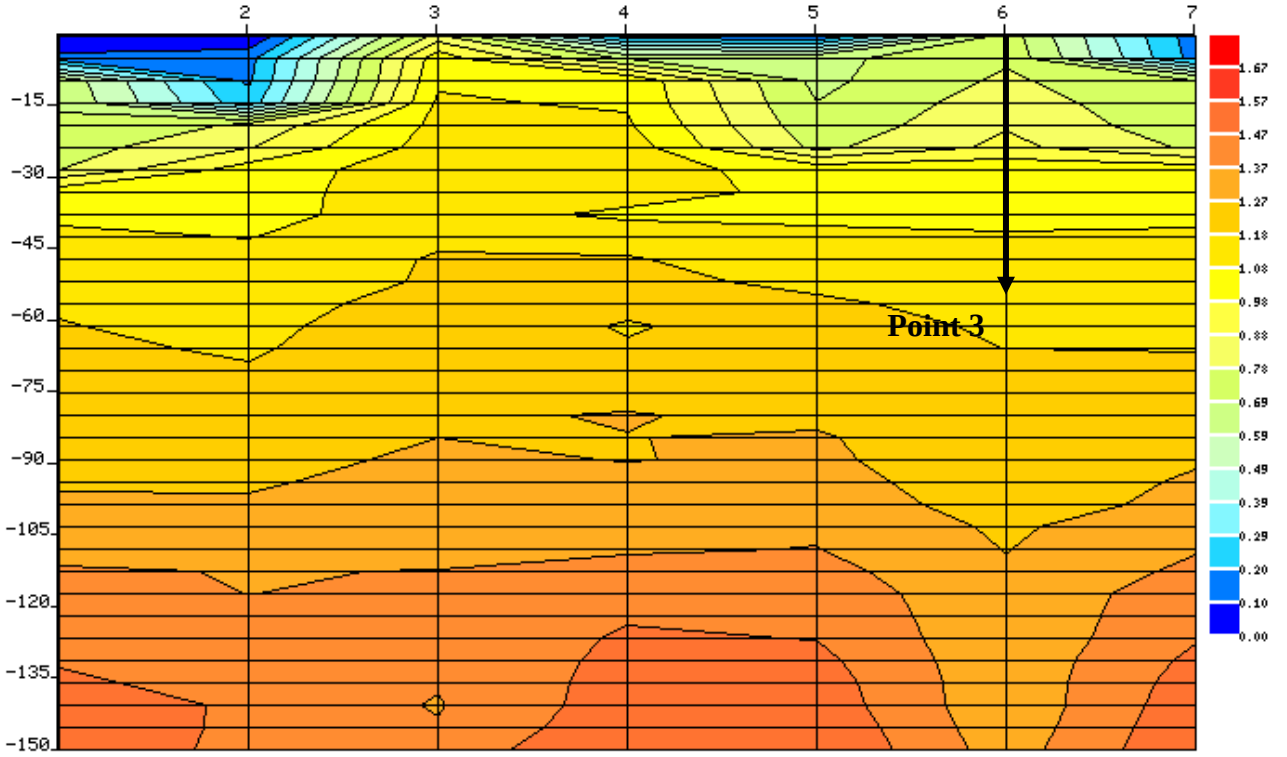

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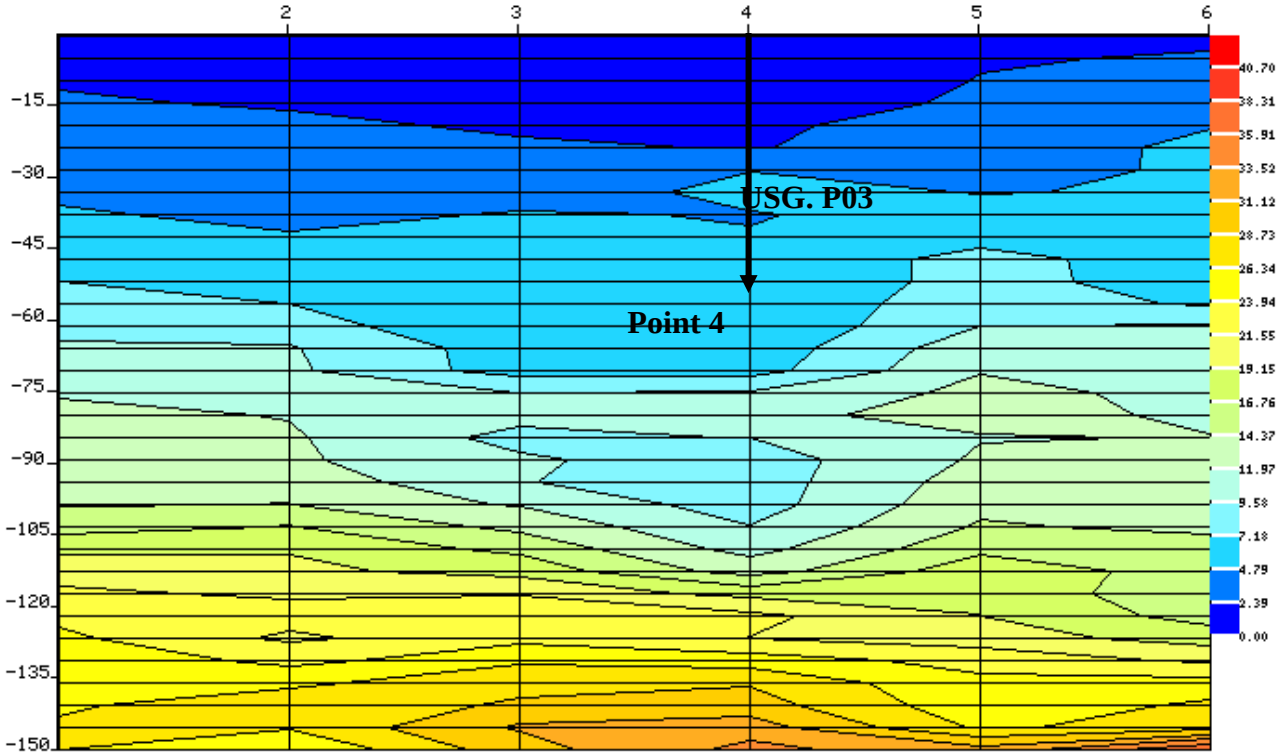
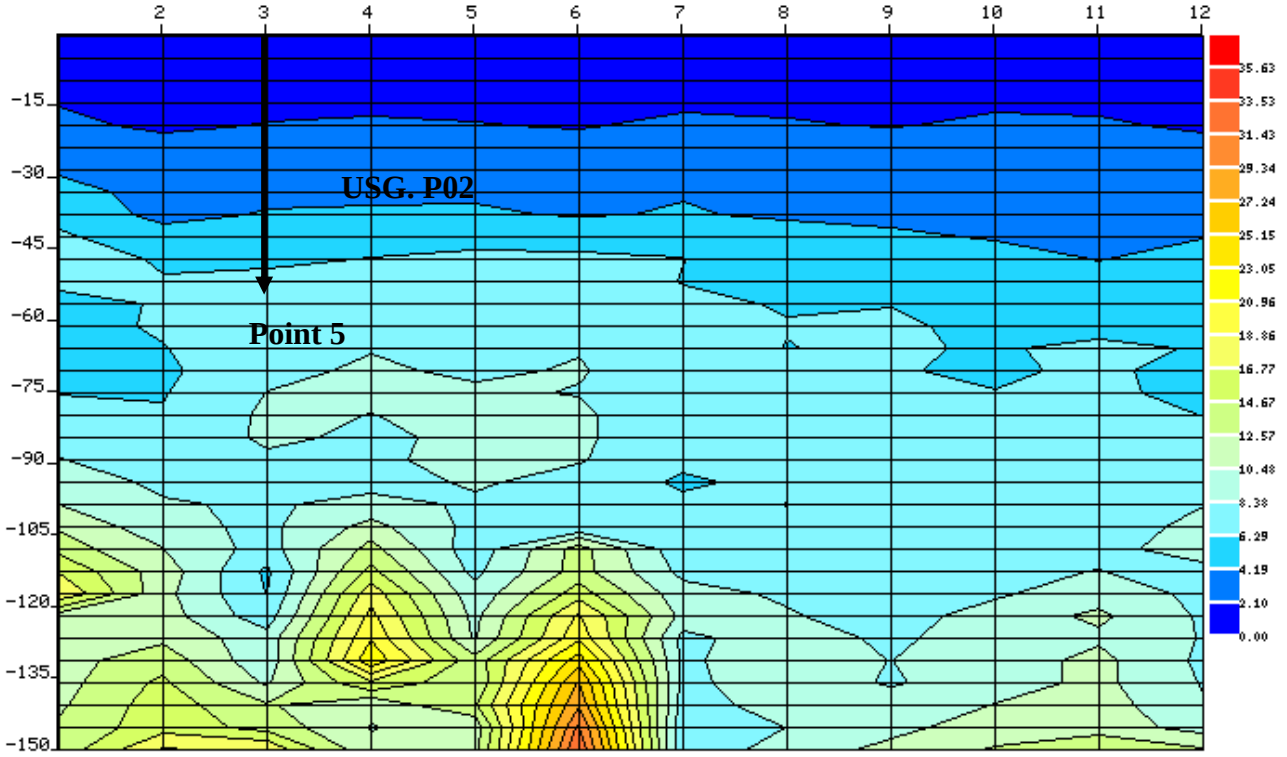
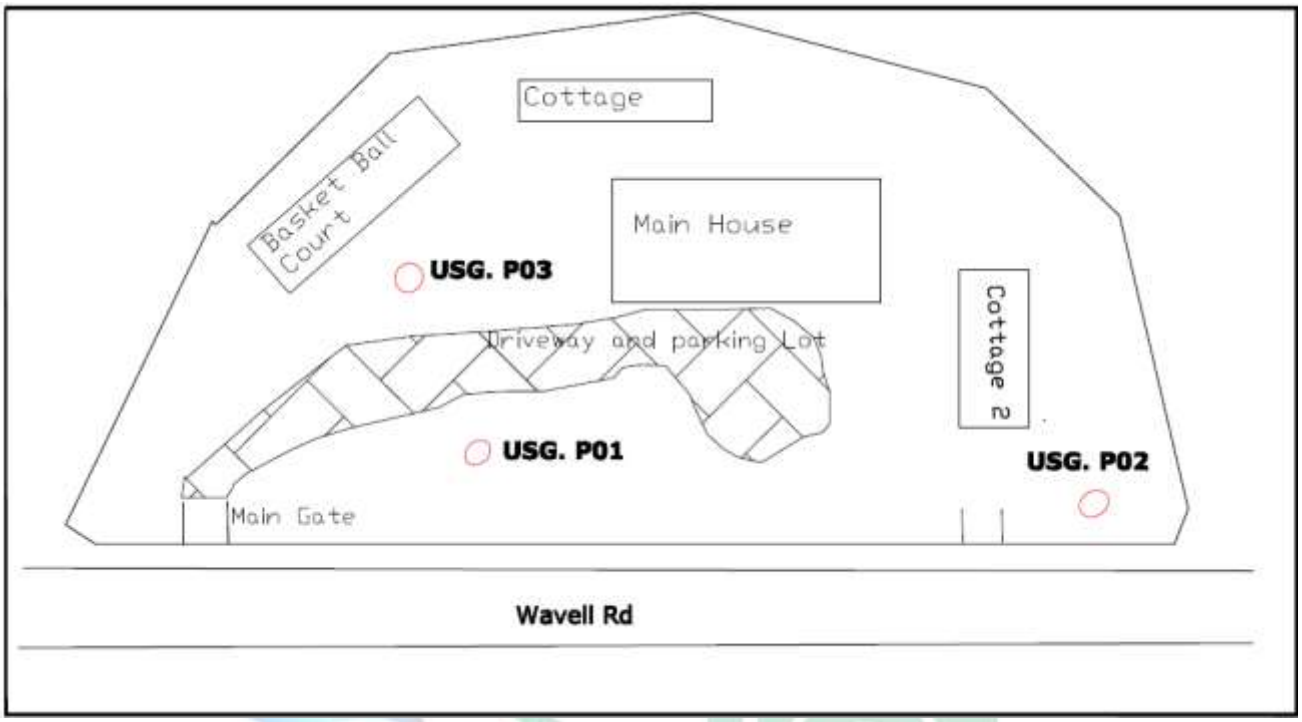


Amanzi Oasis
104 Harare Drive, Harare
+263 772 696 989
+263 786 289 966
+263 779 660 794
sales@amanzioasis.com

Survey line 5



Site Plan ***(Survey pegs and reference points)***



Discussion and Recommendations

On the above profile survey lines, a fairly uniform ground formation across the whole area is noted, showing generally low earth resistivity results from 0 to 50m. Moderately high from 50m to 130m and very high below 140m, signs indicating partial and marginal rock fracturing respectively.

Anomalies that normally represent water bearing streams were detected in the rock formation within 120m but more concentrated within the first 80m below the ground level evidenced by the presence of v- shaped and slight horizontal contour lines representing rock fracturing.

Survey line 1, 2 and 3 were carried out at one meter interval, results showed low resistivity values to greater depths indicating that the bedrock beneath the marked points is highly weathered /fractured.

Point number one, marked Peg 1, extended slight deeper with the lowest resistivity values and this is an indication/ possibility of the existence of a more weathered and porous rock type and/or a network of cracks and joints that allow ground water to flow. Such readings therefore represent both surface and sub-surface potential and normally result in high yielding boreholes. Hence, **point 1/USG. P01** on

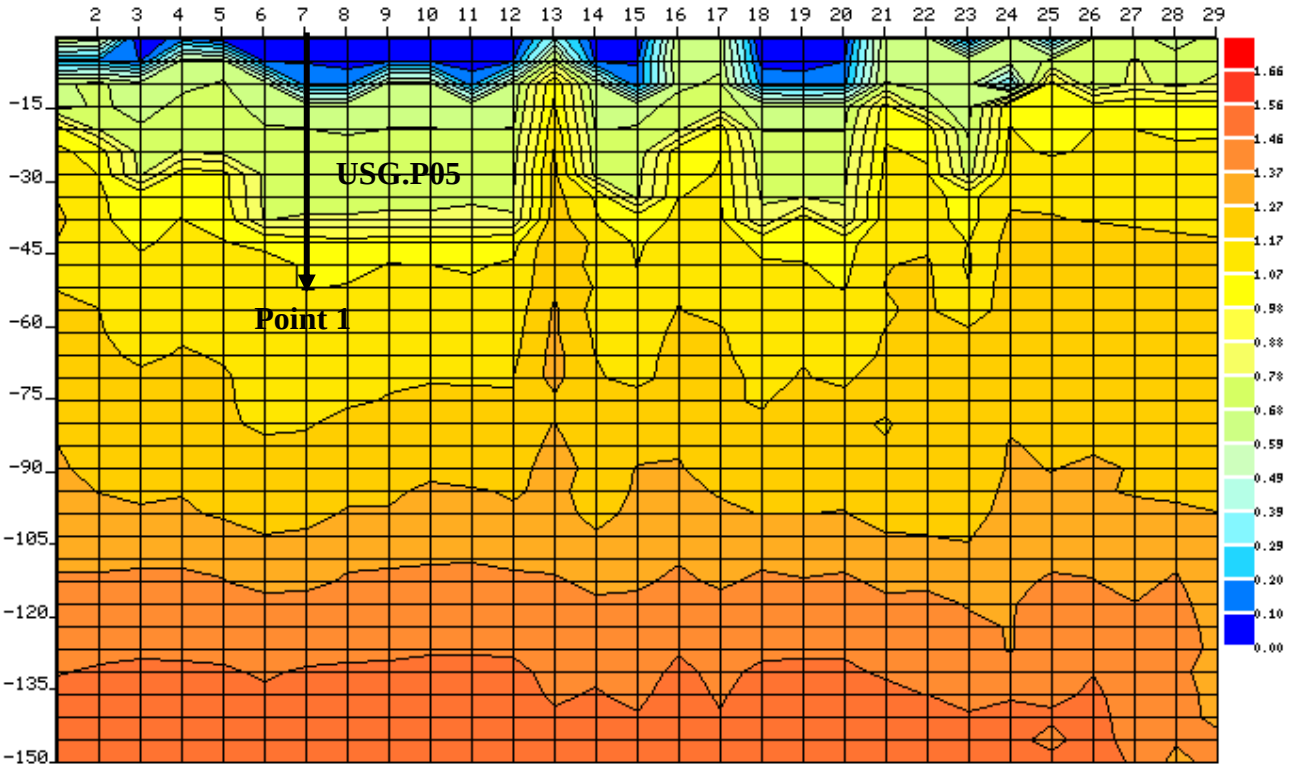
survey line 1 is the best point found during survey for drilling, followed by point 5/USG. P02 on survey line 5, then lastly point 4/USG. P03 on survey line 4.

Minimum and maximum recommended drilling depths are estimated at 90m and 150m respectively.

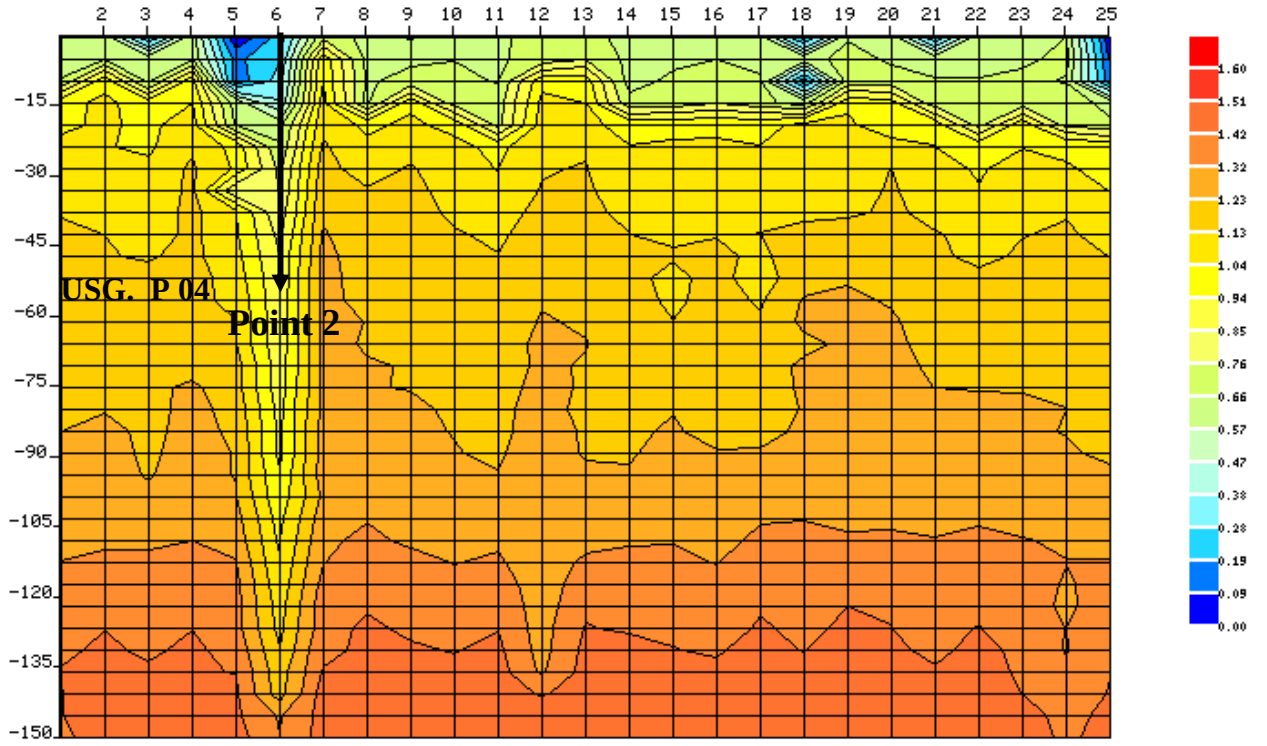
Drilling Order & Preference	Peg No.& Position	Interpretation	Estimated Minimum Depth of Drilling	Expected yield per hour
USG.P01	USG. P01 Site 1	Fracture	90m	±0.42m³
USG.P02	USG. PO2 Site 2	Fracture	110m	±0.42m³
USG.P03	USG. PO3 Site 3	Fracture	120m	±0.29m³

Site 2: 63 Orange drive, Highlands, Harare.

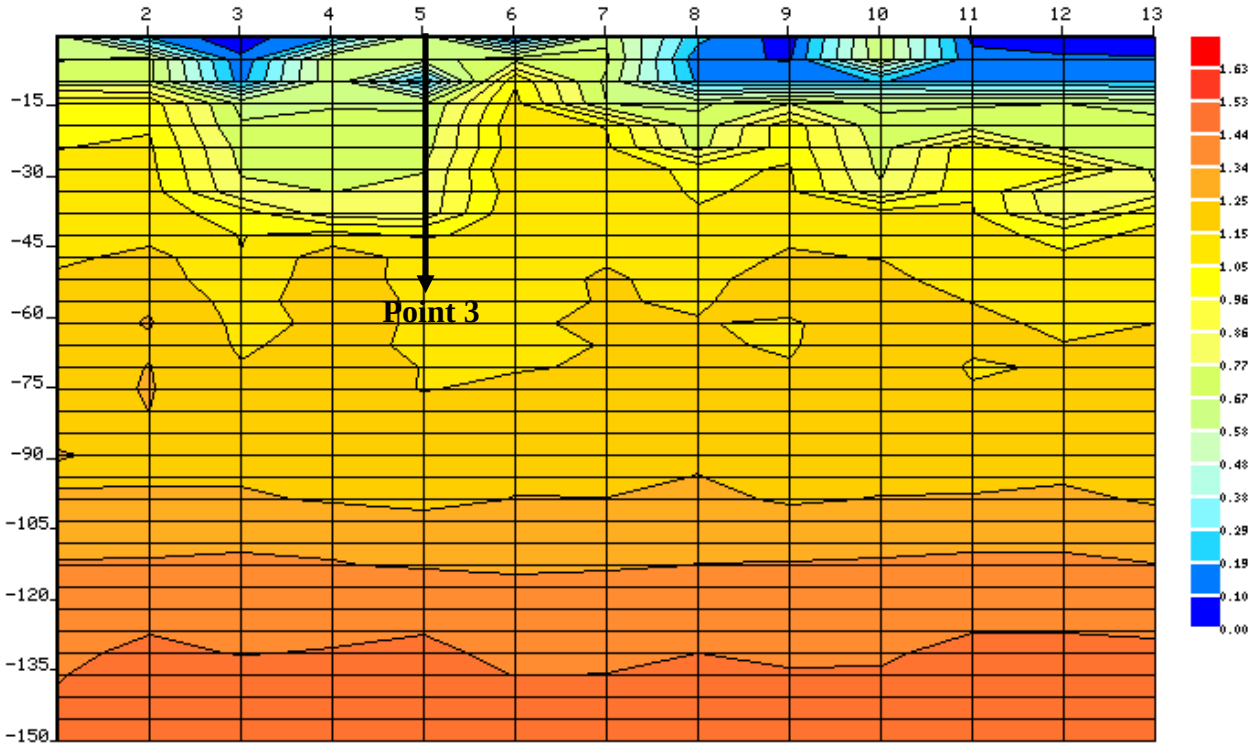
Survey Line 1



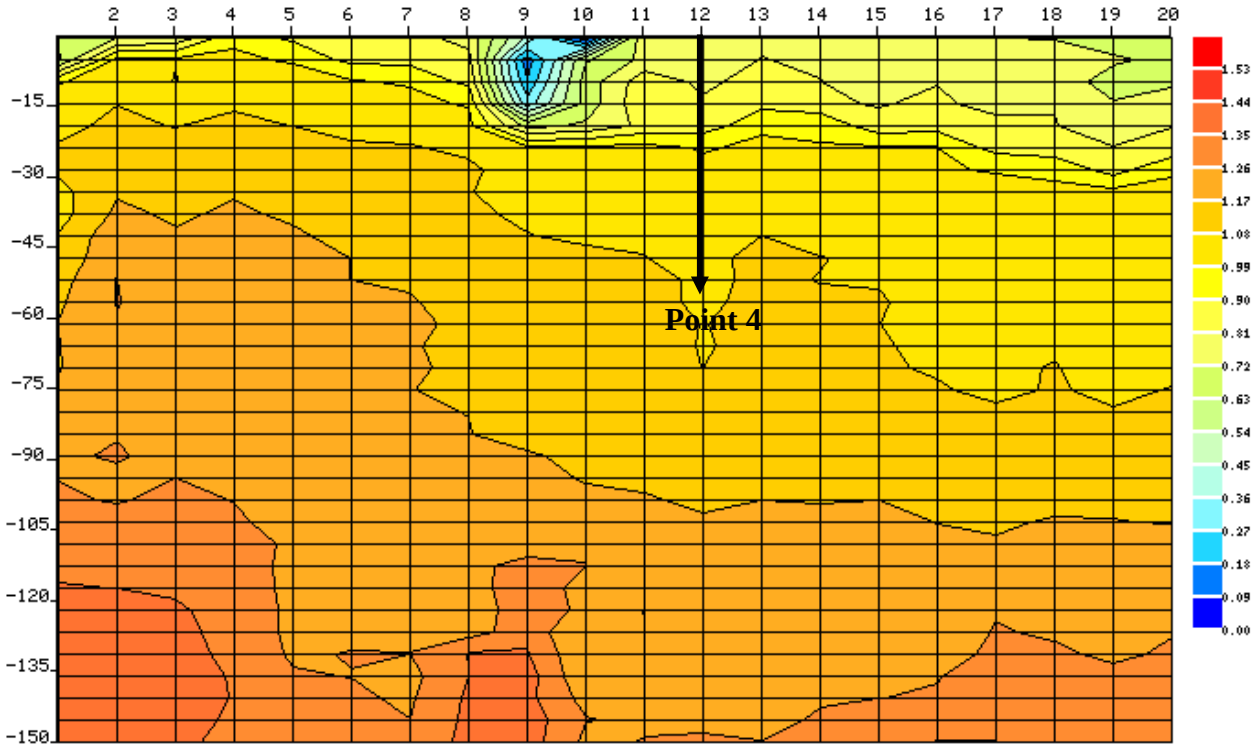
Survey Line 2



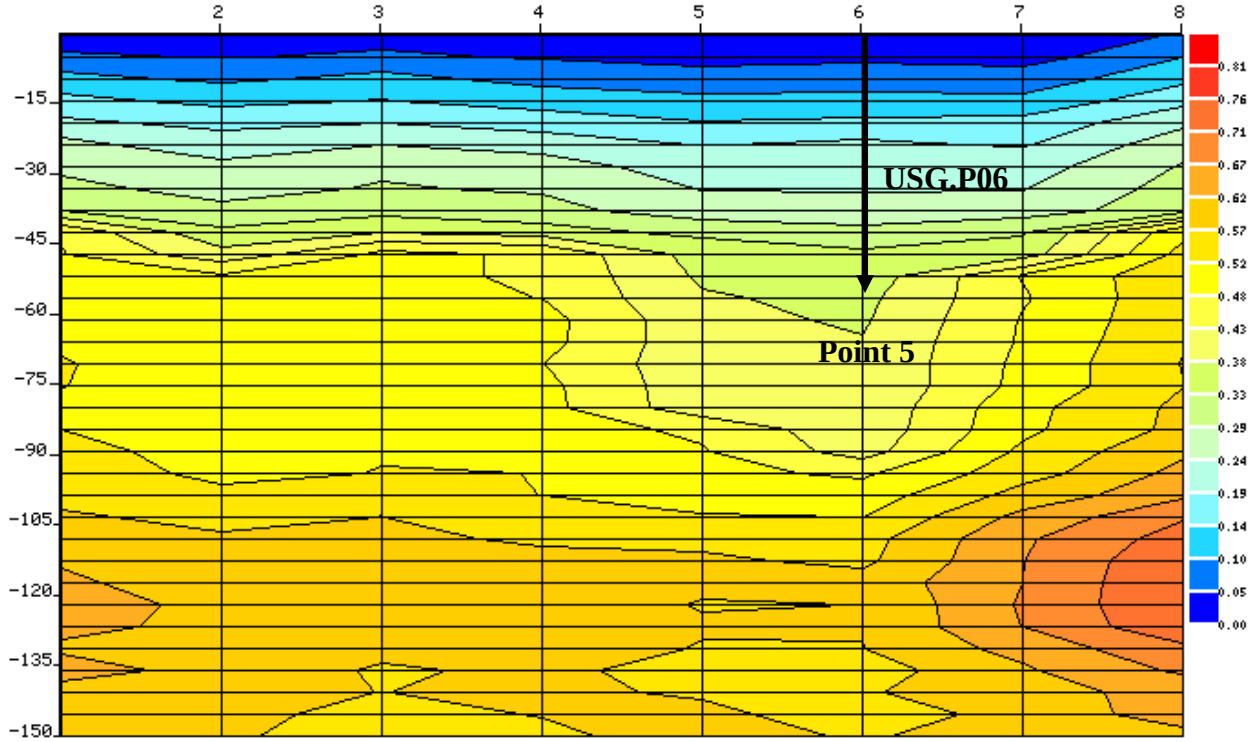
Survey line 3



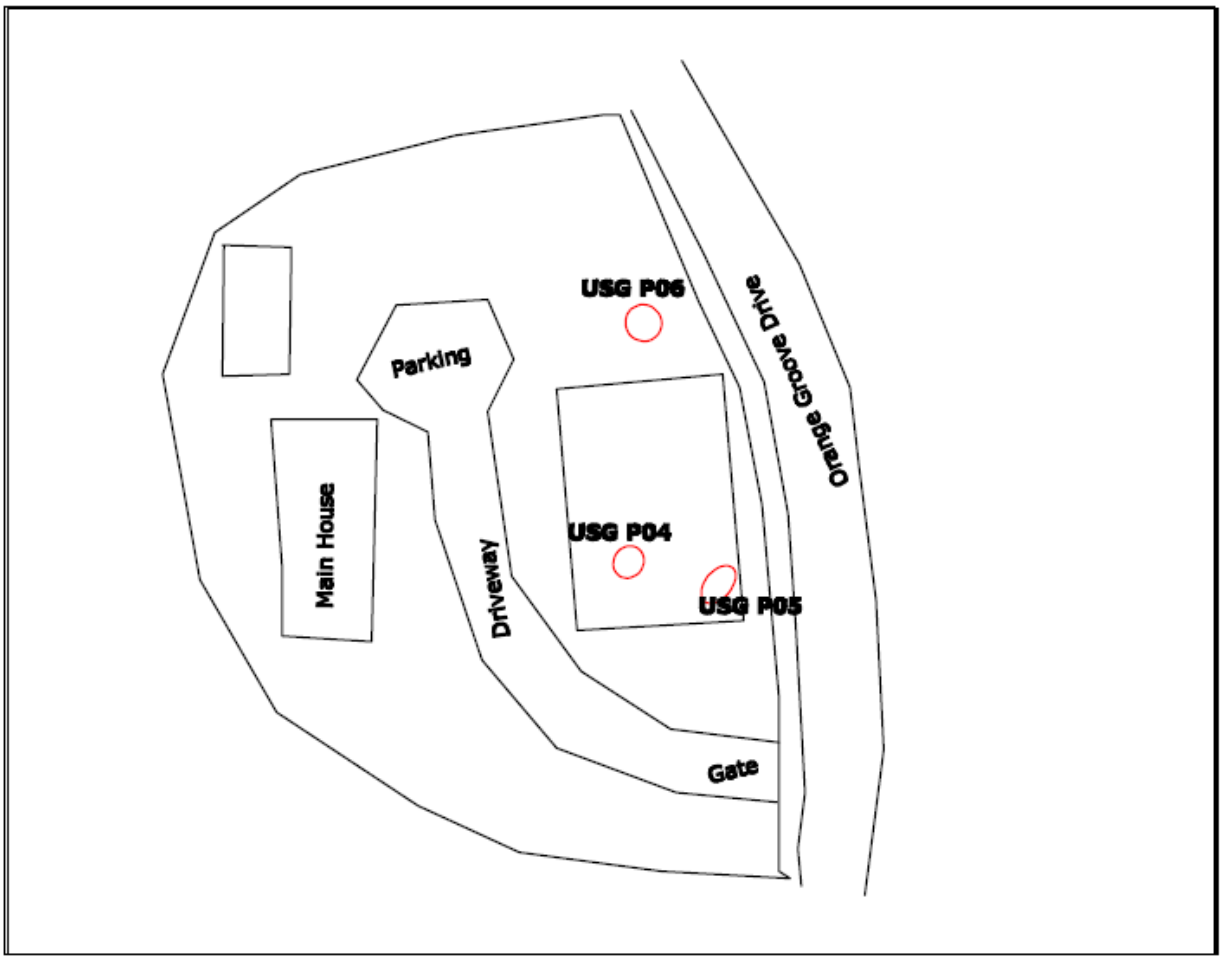
Survey line 4



Survey line 5



Site Plan (Survey pegs and Reference points)



Discussion and Recommendations

The property sits on top of a hill which steeply slopes at about 40 degrees to the south. Several lines were surveyed on both up the hill and on the low-lying parts. Fractures likely to bear underground streams were detected mostly on the low-lying parts of the property, however most of these were shallow indicating minimal fracturing within the bedrock.

On the above profile survey lines, a fairly uniform ground formation across the whole area is noted, showing generally low earth resistivity results from 0 to 30m. Moderately high from 35m to 70m and very high below 80m, signs indicating partial and marginal rock fracturing respectively.

Anomalies that normally represent water bearing streams were detected in the rock formation within

120m but more concentrated within the first 80m below the ground level evidenced by the presence of v- shaped and slight horizontal contour lines representing rock fracturing, clearly seen on survey line 2 USG.P04.

Several survey lines were carried out at one meter interval, results showed that resistivity increases with depth and minimal fracturing withing the lithologies underneath implying.

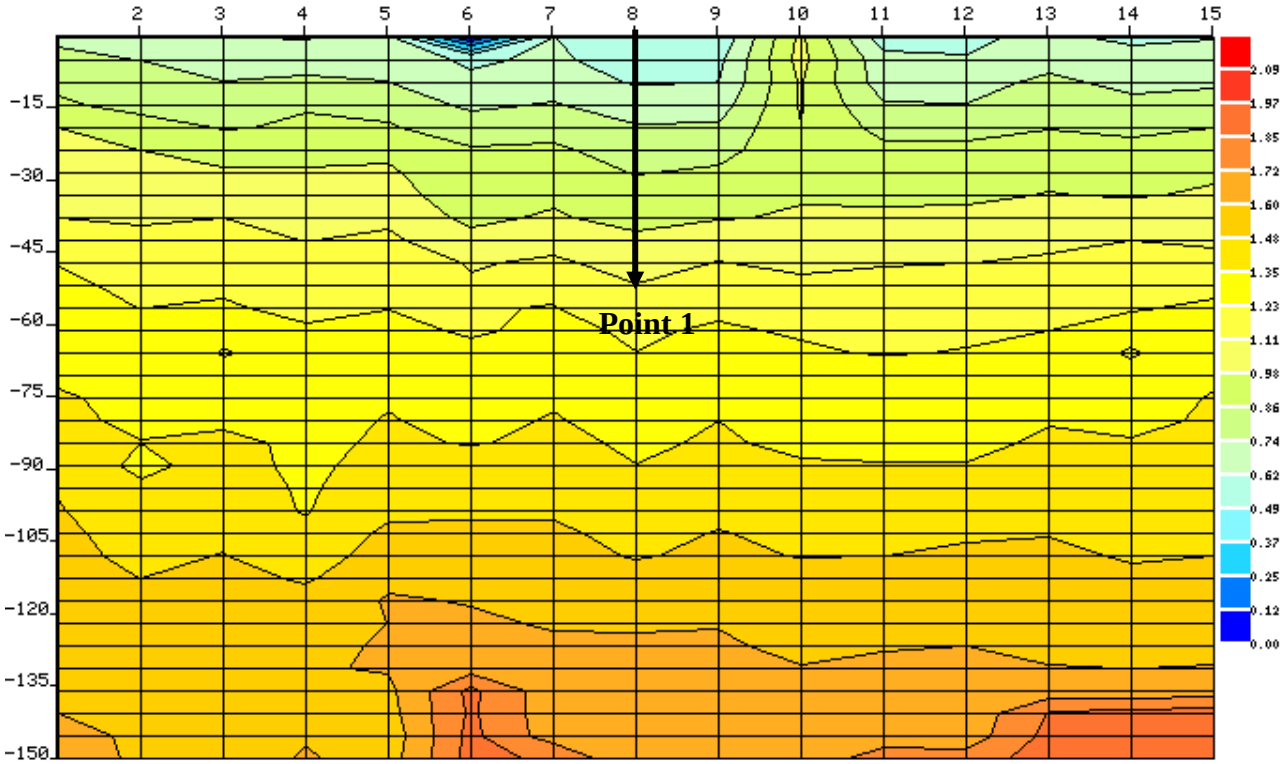
Point number two, marked USG.P04 on survey line 2, extended to greater depths with the lowest resistivity values and this is an indication/ possibility of the existence of a more weathered and porous rock type and/or a network of cracks and joints that allow ground water to flow. Such readings therefore represent both surface and sub-surface potential and normally result in high yielding boreholes. Hence, **point 2/USG.P04** on **survey line 2** is the best point found during survey for drilling, followed by point 1/USG.P05 on survey line 1, then lastly point 5/USG.P06 on survey line 5.

Minimum and maximum recommended drilling depths are estimated at 90m and 130m respectively.

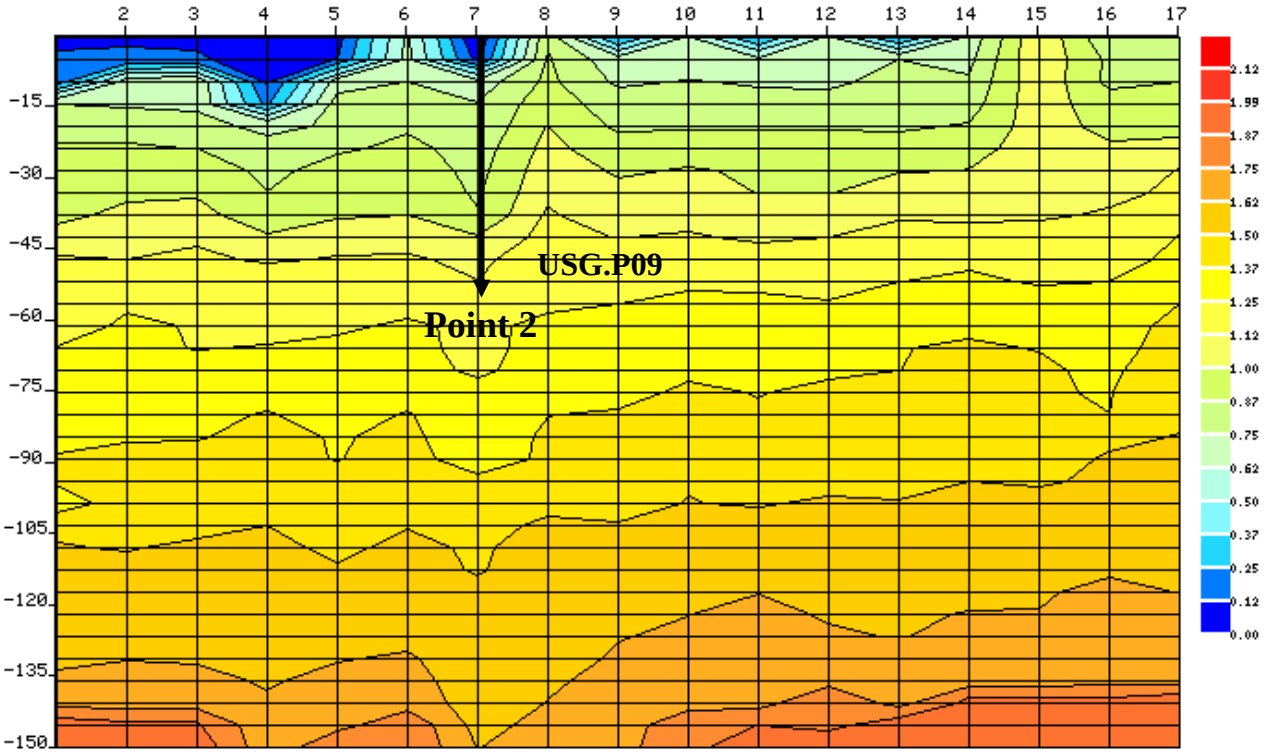
Drilling Order & Preference	Peg No.& Position	Interpretation	Estimated Minimum Depth of Drilling	Expected yield per hour
USG. P04	USG. P04 Site 2	Fracture	90m	±0.42m³
USG. P05	USG. P05 Site 1	Fracture	110m	±0.42m³
USG.P06	USG. P06 Site 5	Fracture	110m	±0.42m³

Site 3: 5 Evelyn, Mount Pleasant, Harare

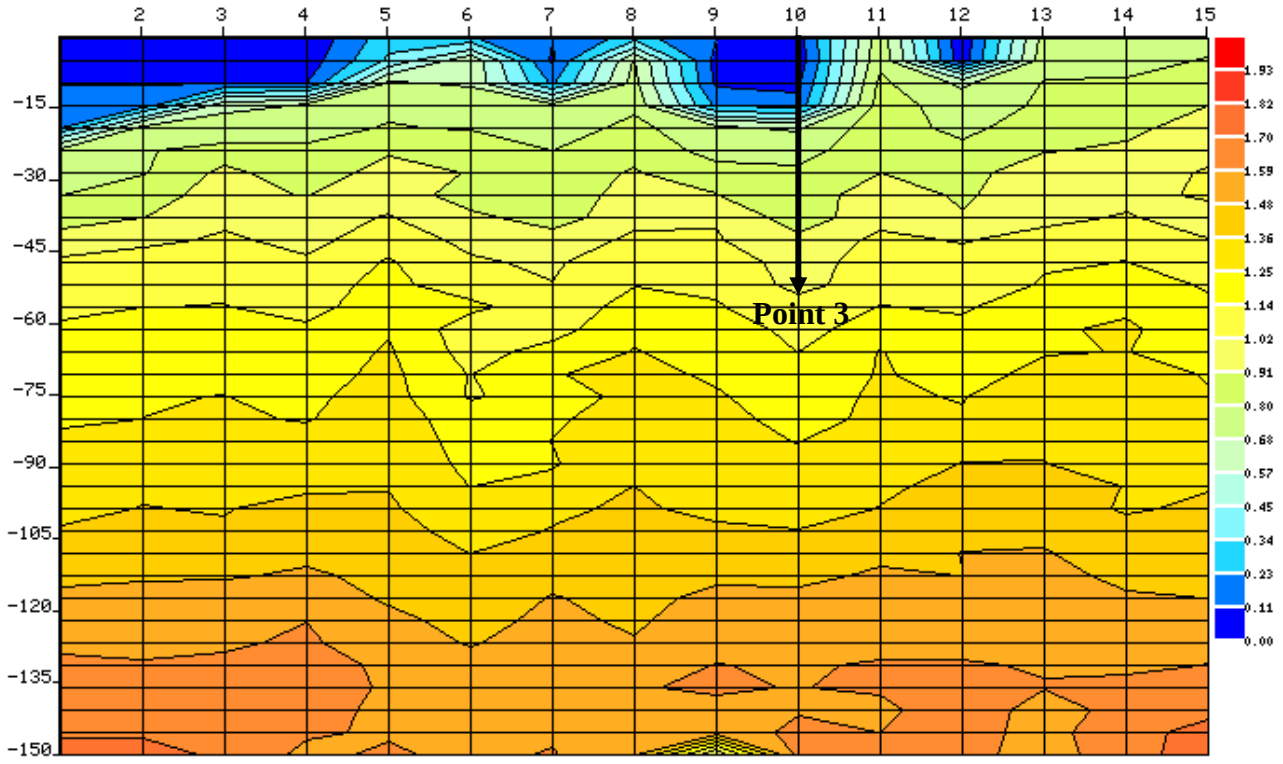
Survey Line 1



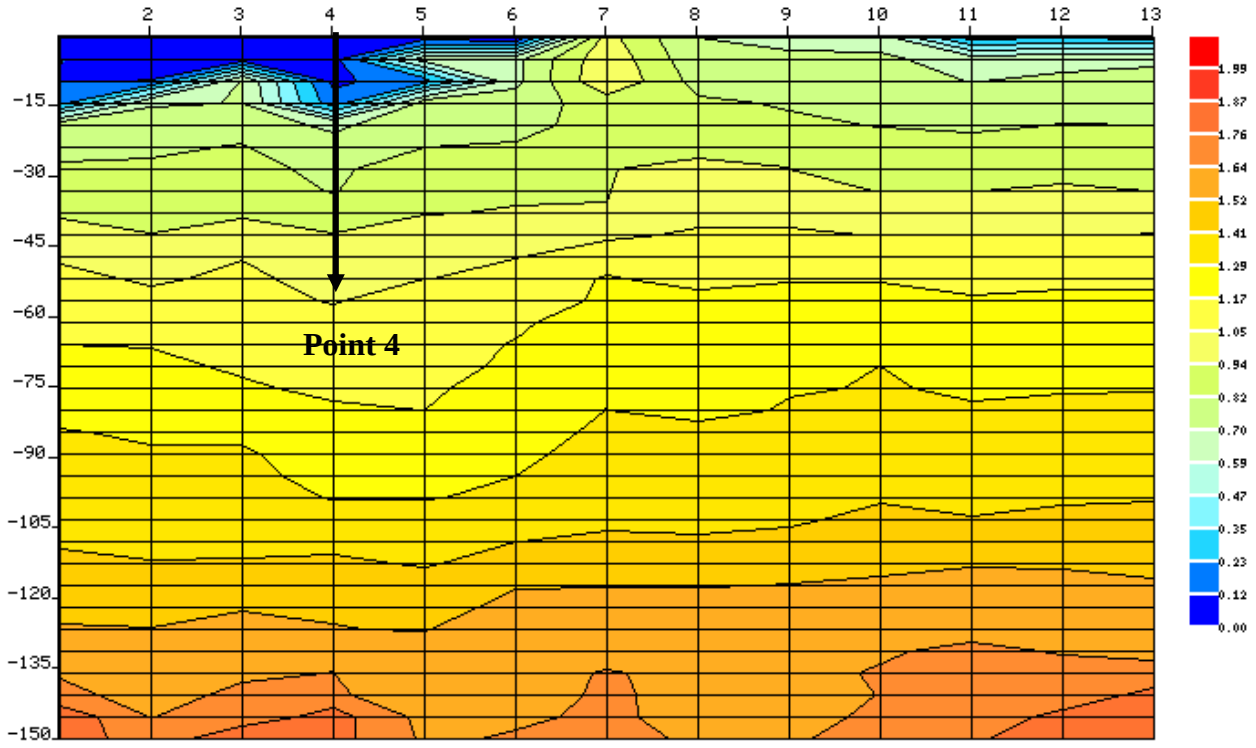
Survey Line 2



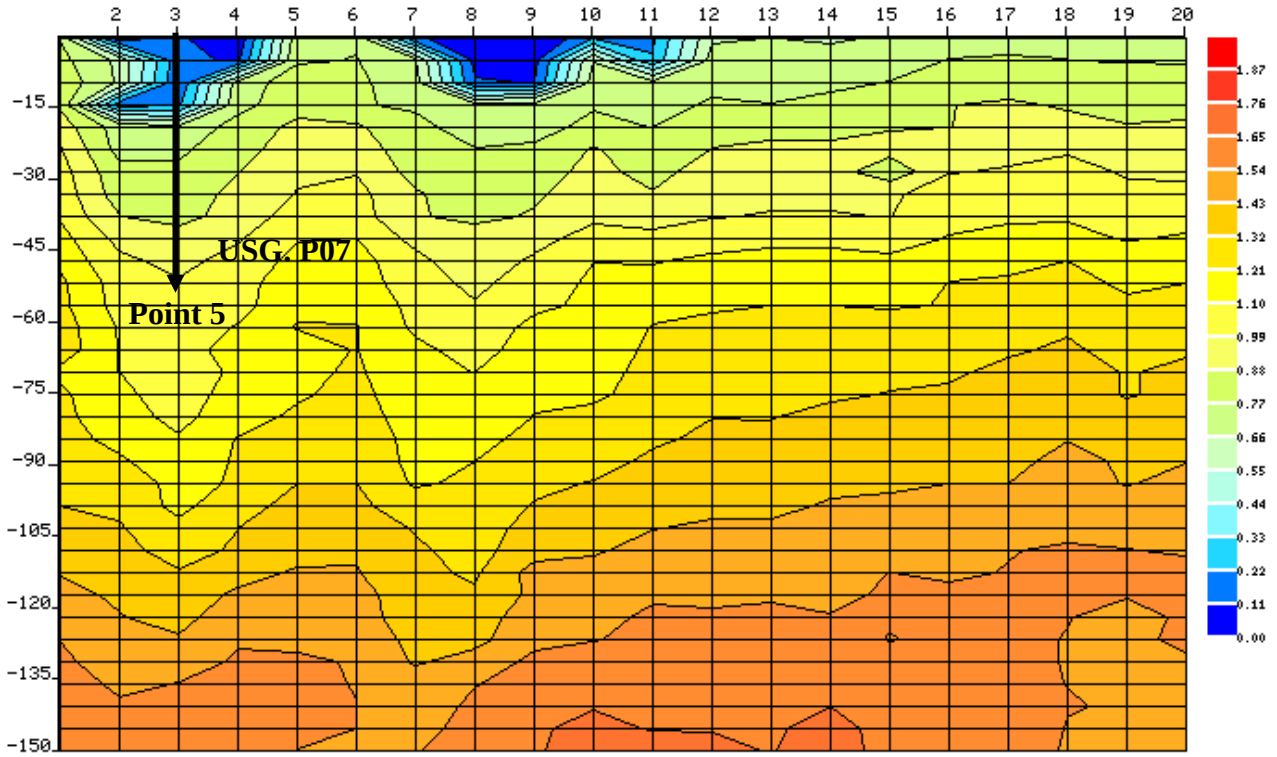
Survey line 3



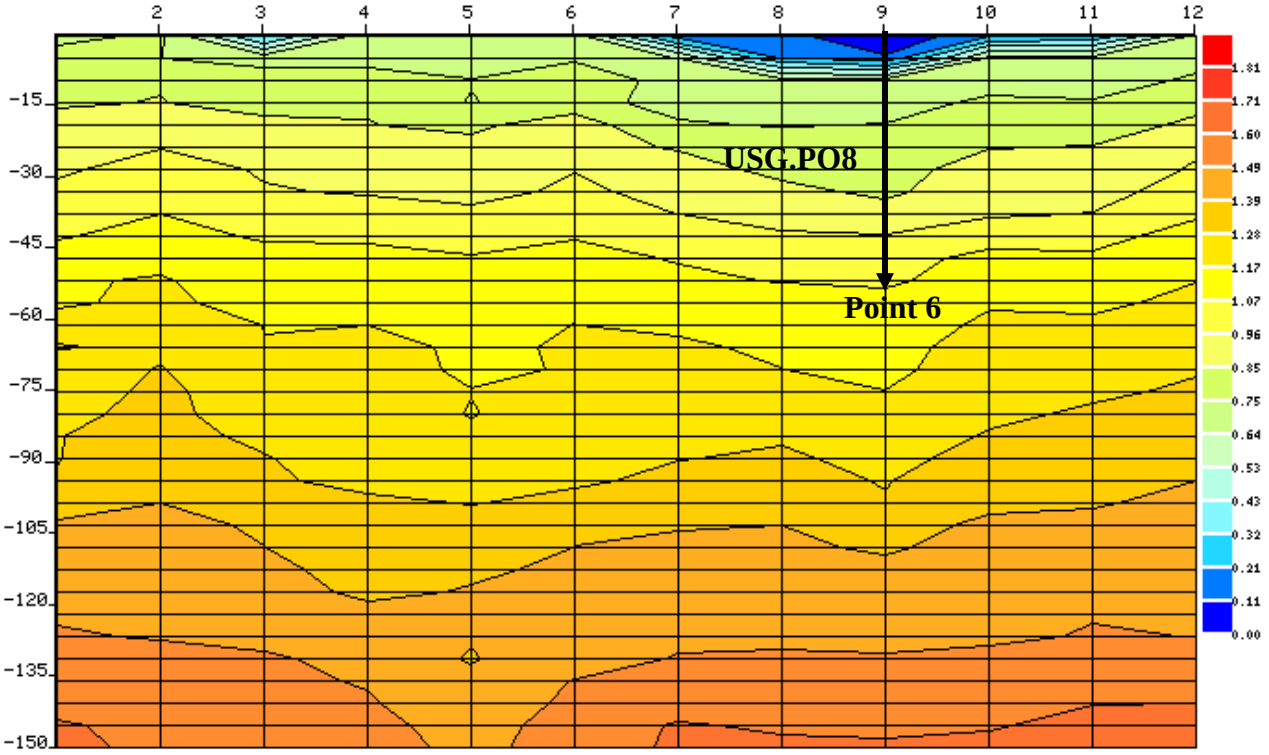
Survey line 4



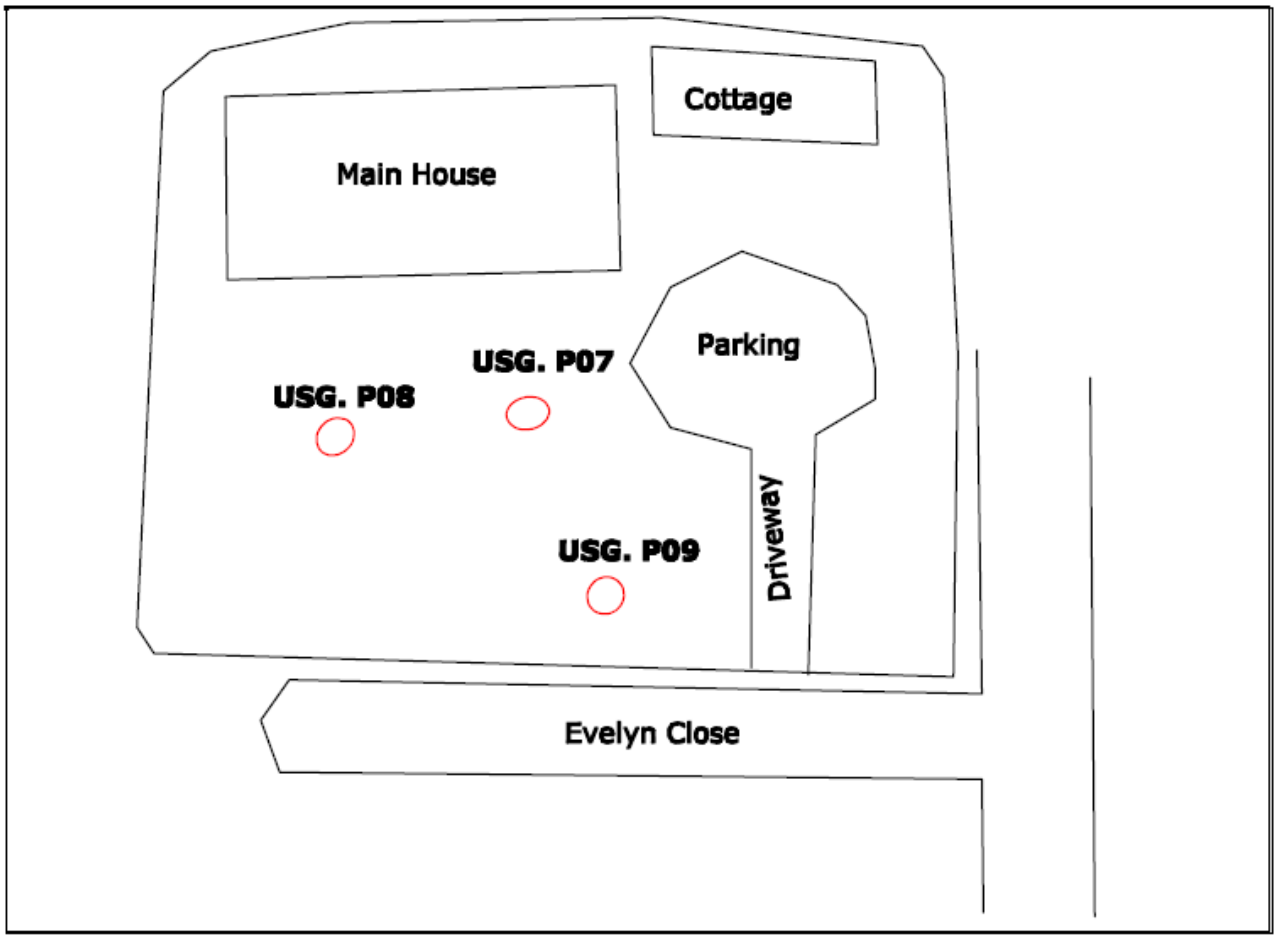
Survey line 5



Survey line 6



Site Plan (Survey Pegs and Reference Points)



Discussion and Recommendations

On the above profile survey lines, a fairly uniform ground formation across the whole area is noted, showing generally low earth resistivity results from 0 to 15m. Moderately high from 20m to 75m and very high below 80m, signs indicating partial and marginal rock fracturing respectively.

Anomalies that normally represent water bearing streams were detected in the rock formation within 105m but more concentrated within the first 70m below the ground level evidenced by the presence of v- shaped and slight horizontal contour lines representing rock fracturing, clearly seen on survey line 5 peg USG.P07.

Several survey lines were carried out at one meter interval, results showed that resistivity increases with depth and minimal fracturing withing the lithologies underneath implying.

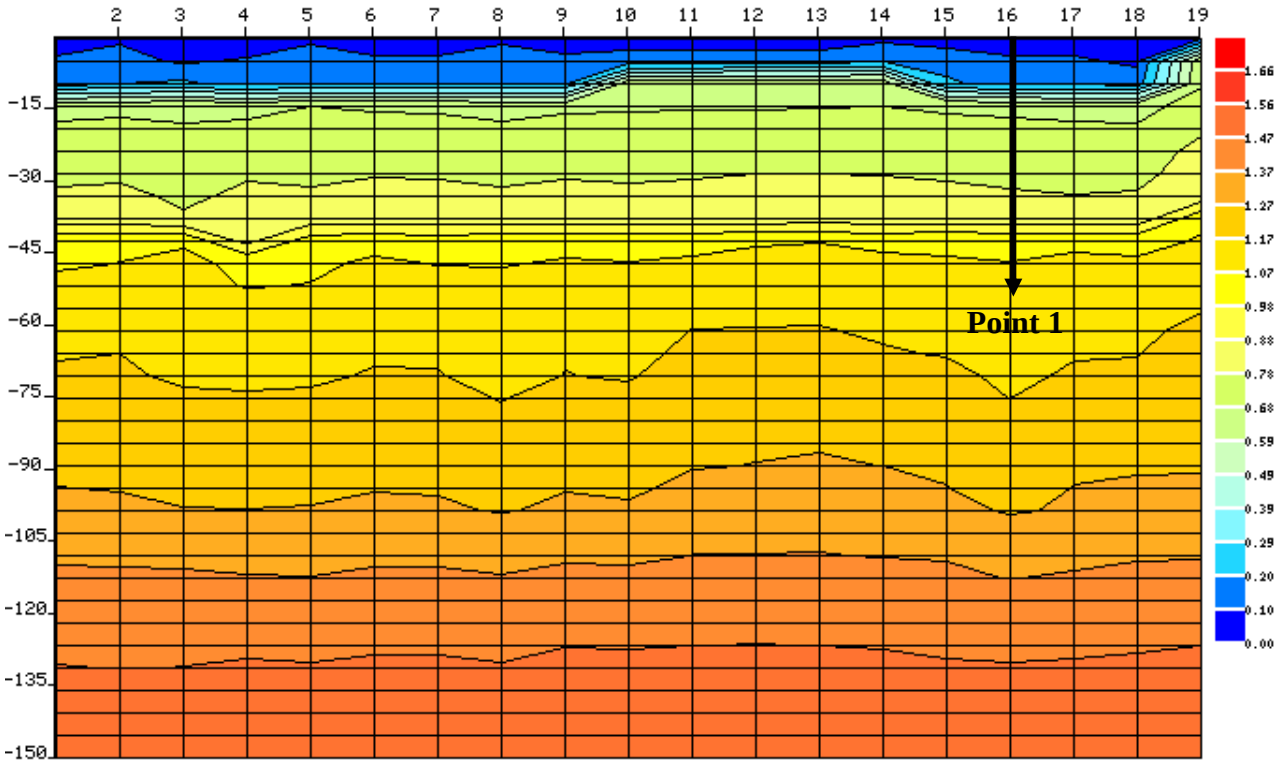
Point number five, marked Peg USG.P07 on survey line 5, extended to greater depths with the lowest resistivity values and this is an indication/ possibility of the existence of a more weathered and porous rock type and/or a network of cracks and joints that allow ground water to flow. Such readings therefore represent both surface and sub-surface potential and normally result in high yielding boreholes. Hence, **point 5/Peg USG.P07** on **survey line 5** is the best point found during survey for drilling, followed by point 6/peg USG.P08 on survey line 6, then lastly point 2/peg USG.P09 on survey line 2.

Minimum and maximum recommended drilling depths are estimated at 70m and 140m respectively.

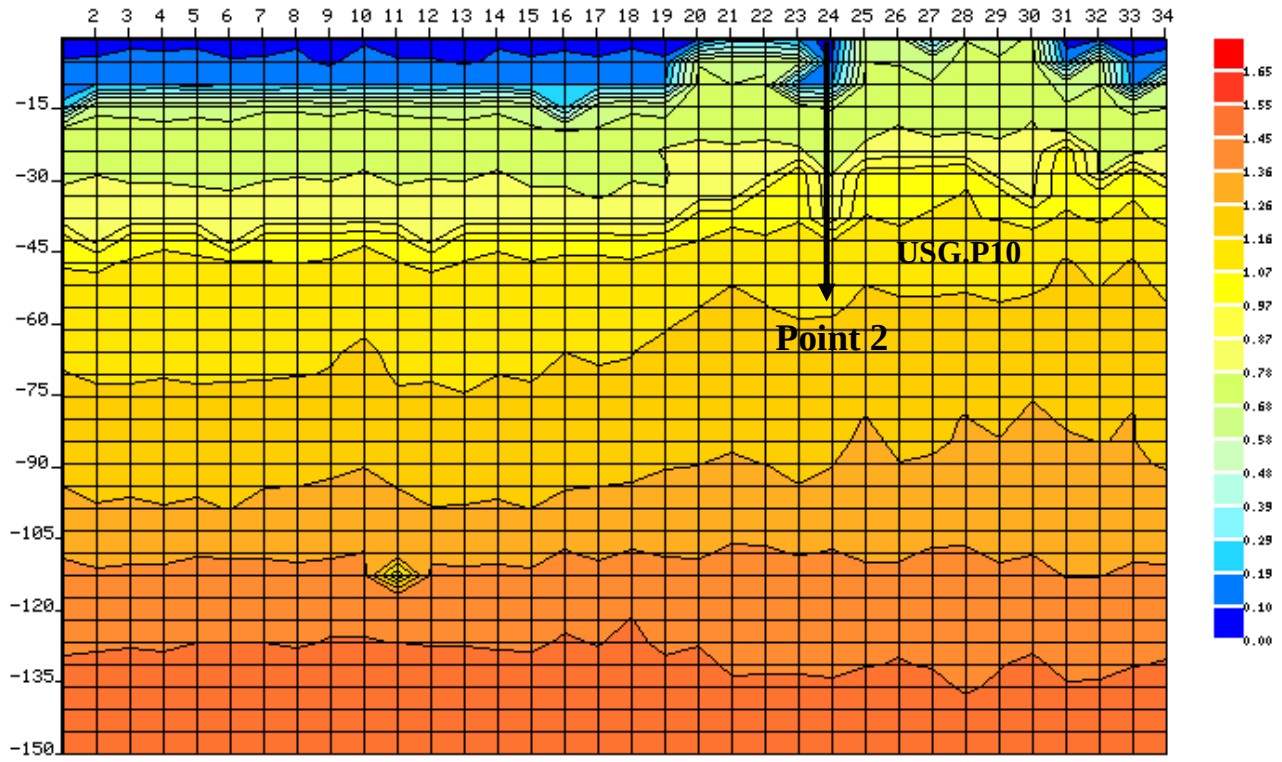
Drilling Order & Preference	Peg No.& Position	Interpretation	Estimated Minimum Depth of Drilling	Expected yield per hour
USG. P07	USG. P07 Site 5	Fracture	70m	±0.83m³
USG. P08	USG. P08 Site 6	Fracture	90m	±0.63m³
USG.P09	USG. P09 Site 2	Fracture	90m	±0.63m³

Site 4: 3 Don close, Highlands, Harare.

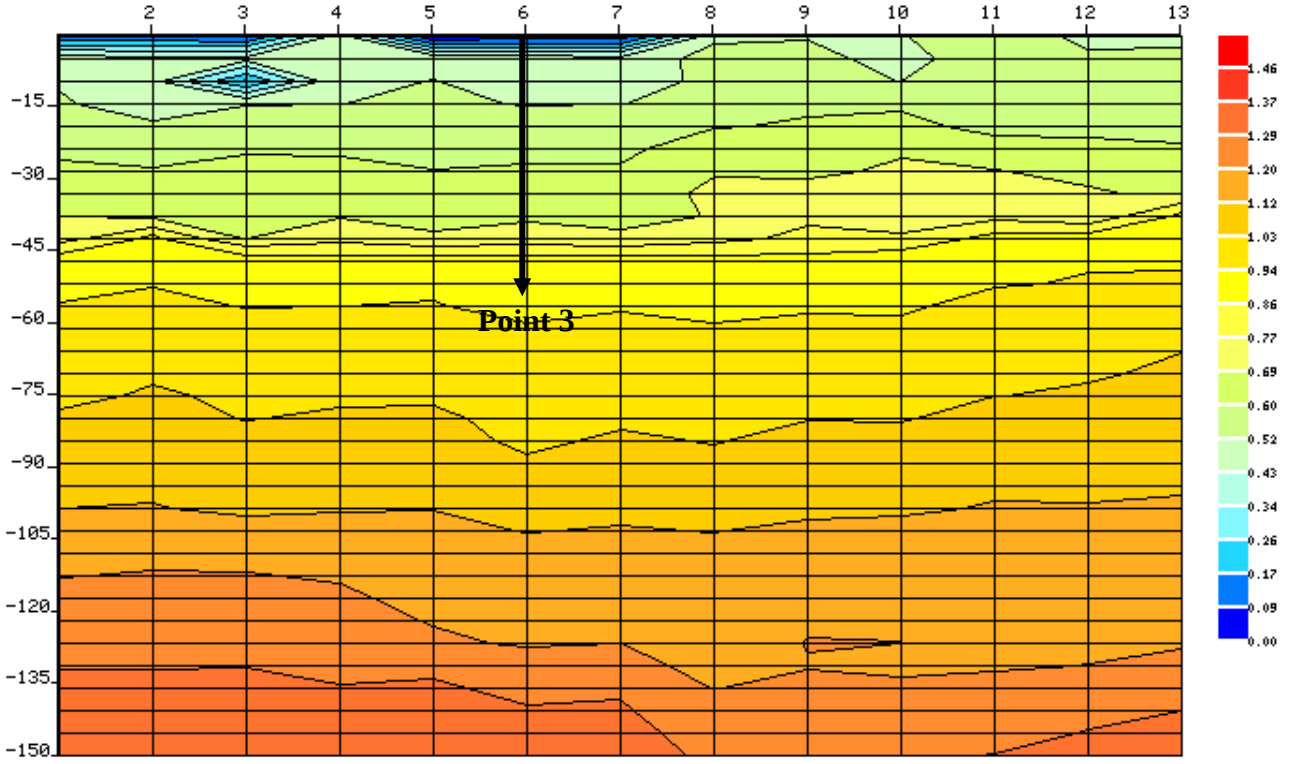
Survey Line 1



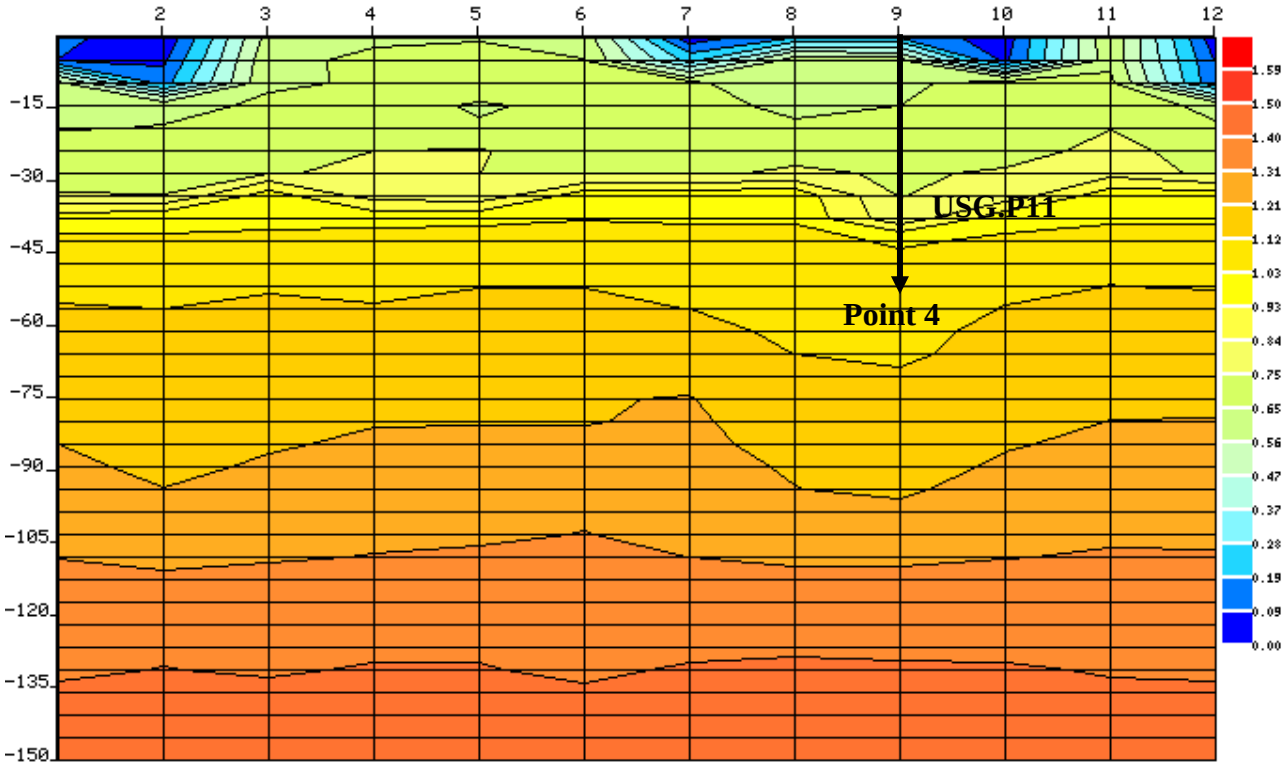
Survey Line 2



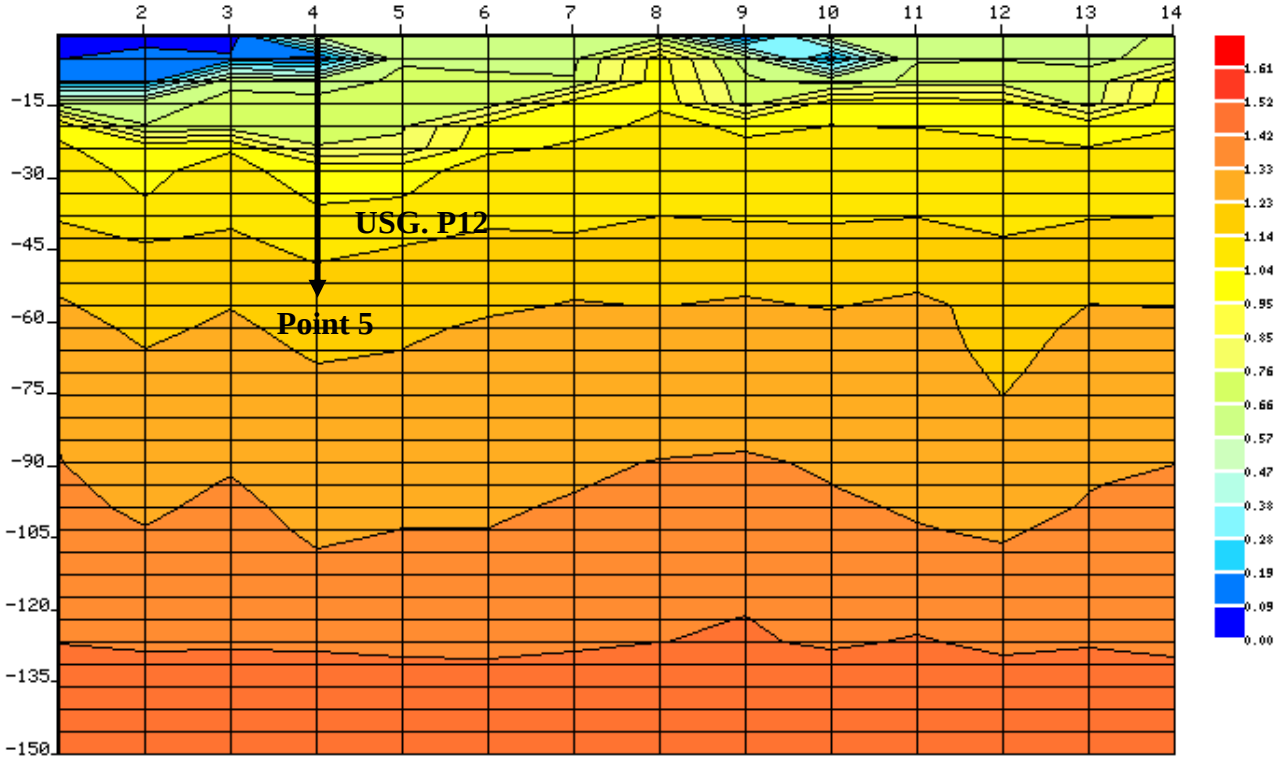
Survey line 3



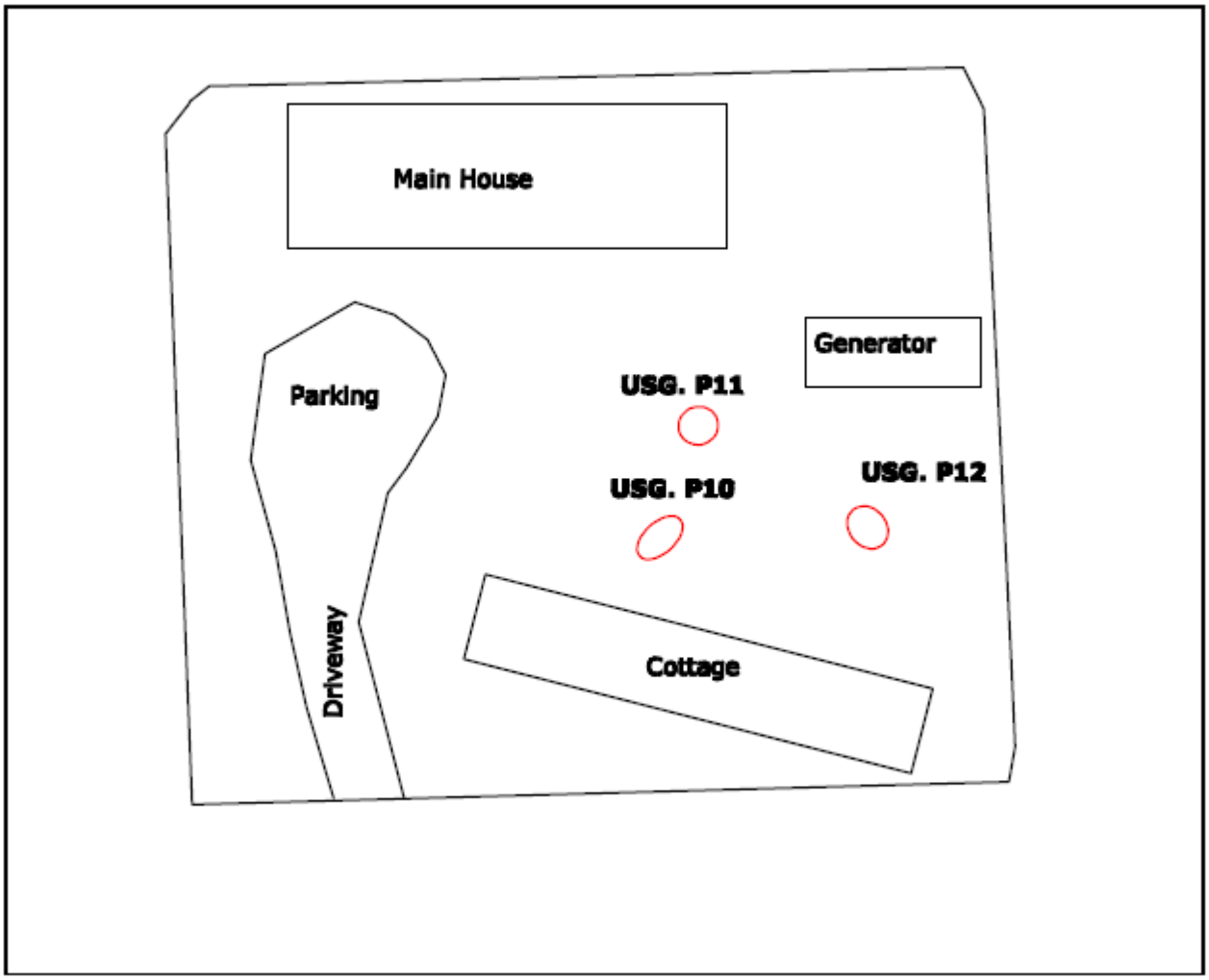
Survey line 4



Survey line 5



Site Plan (Survey pegs and Reference points)



Discussion and Recommendations

On the above profile survey lines, a fairly uniform ground formation across the whole area is noted, showing generally low earth resistivity results from 0 to 30m. Moderately high from 35m to 60m and very high below 70m, signs indicating partial and marginal rock fracturing respectively.

Anomalies that normally represent water bearing streams were detected in the rock formation within 100m but more concentrated within the first 50m below the ground level evidenced by the presence of v- shaped and slight horizontal contour lines representing rock fracturing, clearly seen on survey line 4 peg USG.P11

Several survey lines were carried out at one meter interval, results showed that resistivity increases with depth and minimal fracturing withing the lithologies underneath implying.

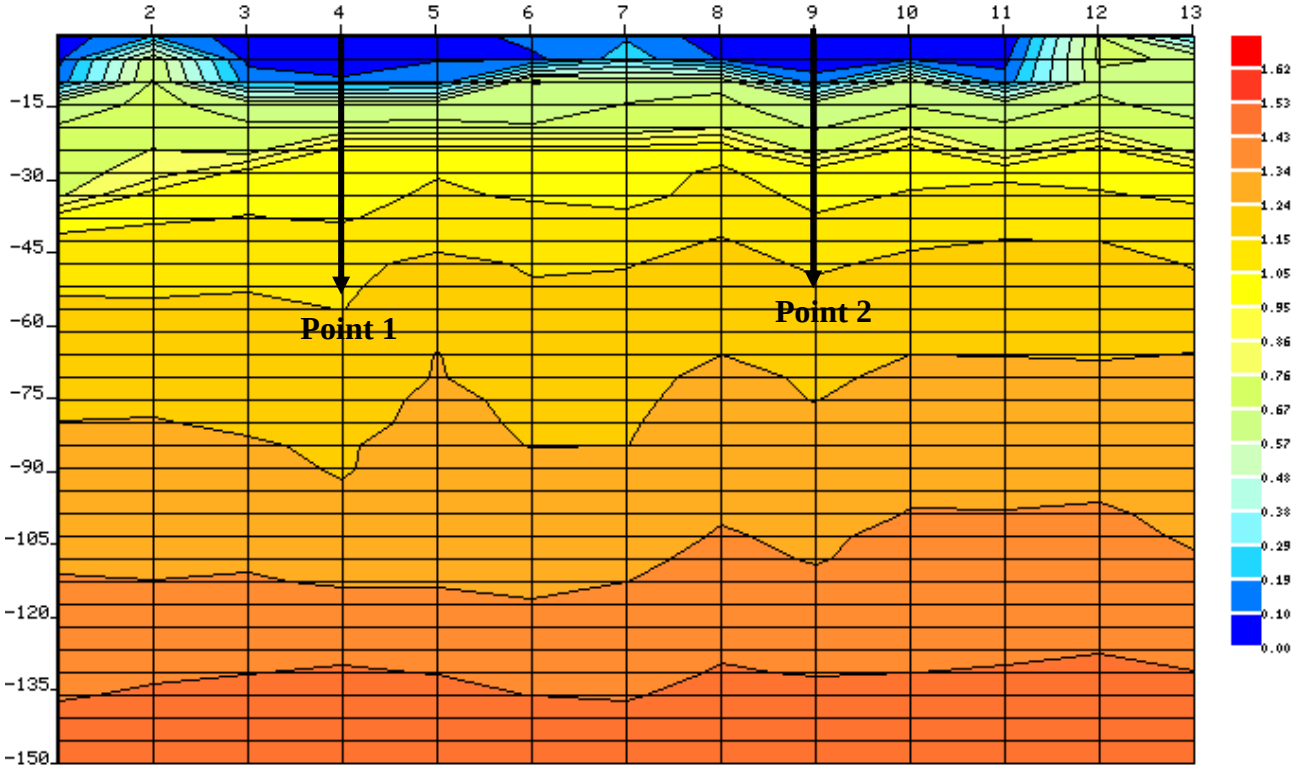
Point number two, USG.P10 on survey line 2, extended to greater depths with the lowest resistivity values and this is an indication/ possibility of the existence of a more weathered and porous rock type and/or a network of cracks and joints that allow ground water to flow. Such readings therefore represent both surface and sub-surface potential and normally result in high yielding boreholes. Hence, **point 2/USG.P10** on **survey line 2** is the best point found during survey for drilling, followed by point 4/USG.P11 on survey line 4, then lastly point 5/USG. P12 on survey line 5.

Minimum and maximum recommended drilling depths are estimated at 80m and 150m respectively.

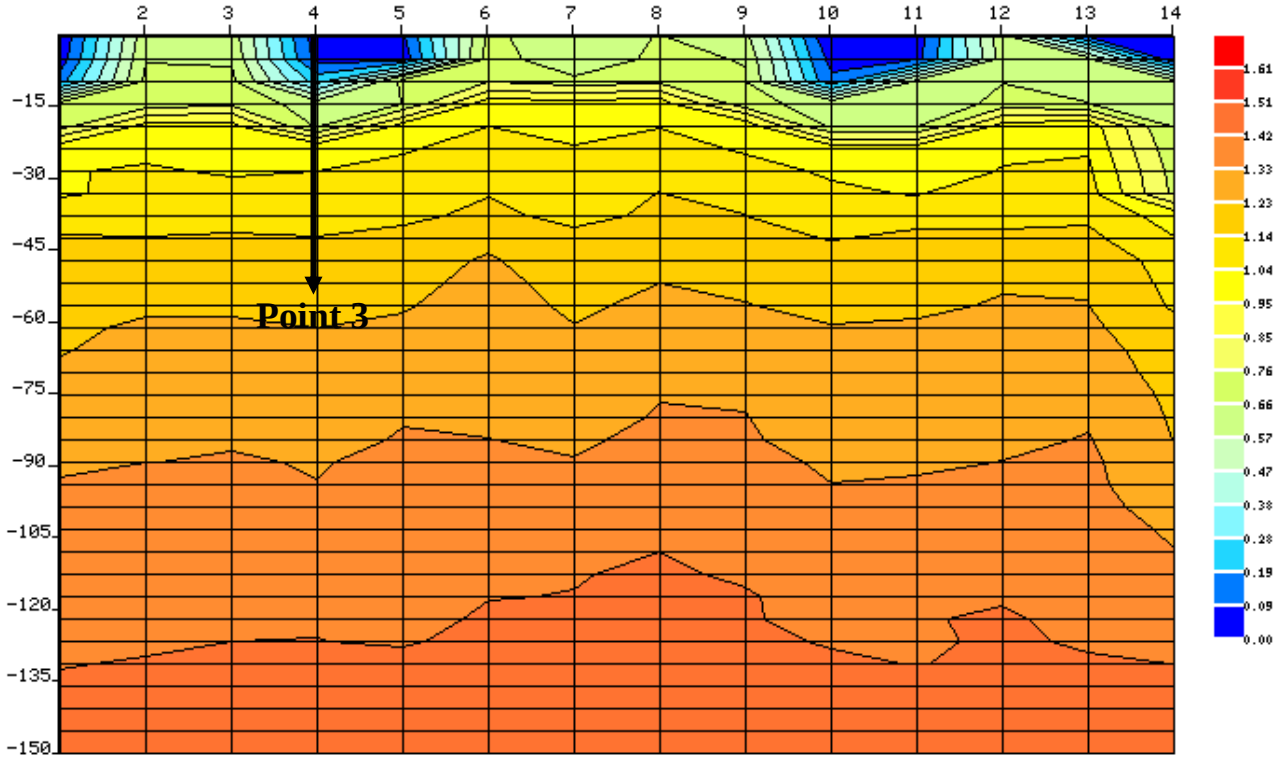
Drilling Order & Preference	Peg No.& Position	Interpretation	Estimated Maximum Depth of Drilling	Expected yield per hour
USG. P10	USG. P10 Site 2	Fracture	80m	±0.63m³
USG. P11	USG. P11 Site 4	Fracture	90m	±0.63m³
USG.P12	USG. P12 Site 5	Fracture	90m	±0.63m³

Site 5: 12 Glenara, Highlands, Harare.

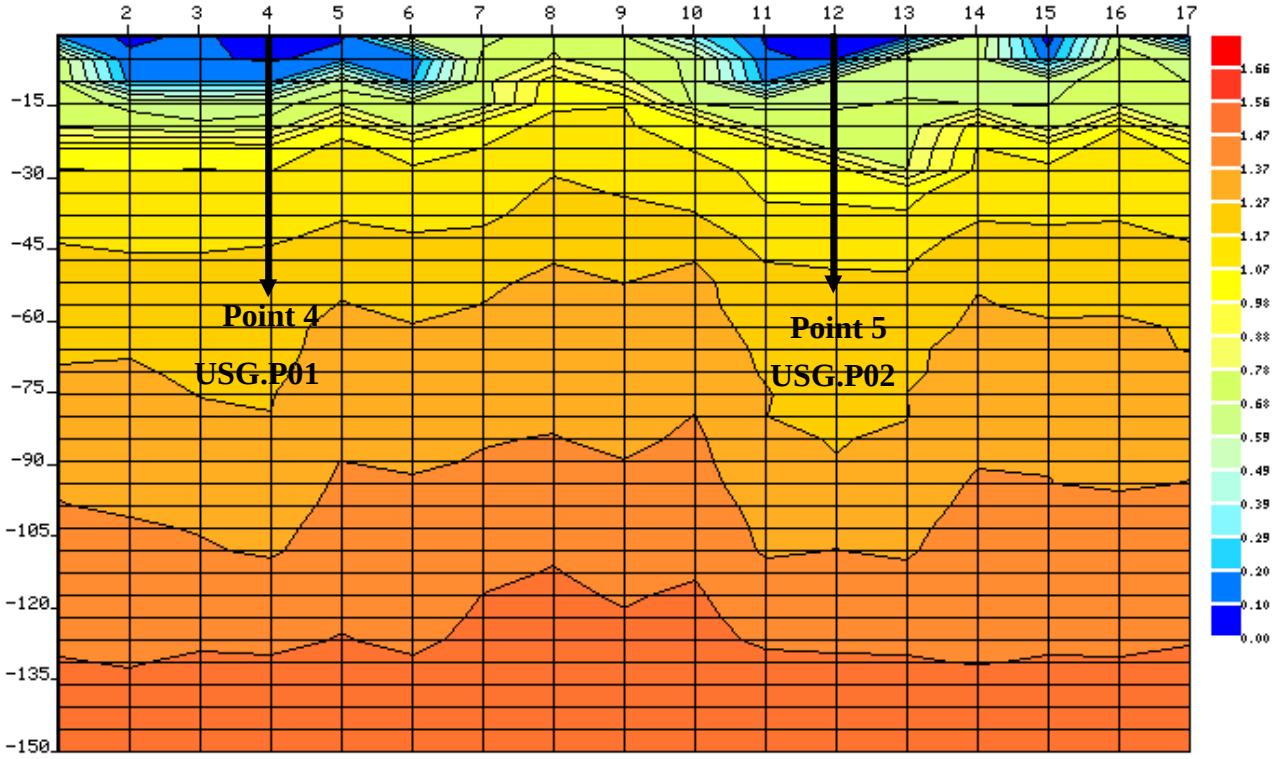
Survey Line 1



Survey Line 2



Survey line 3



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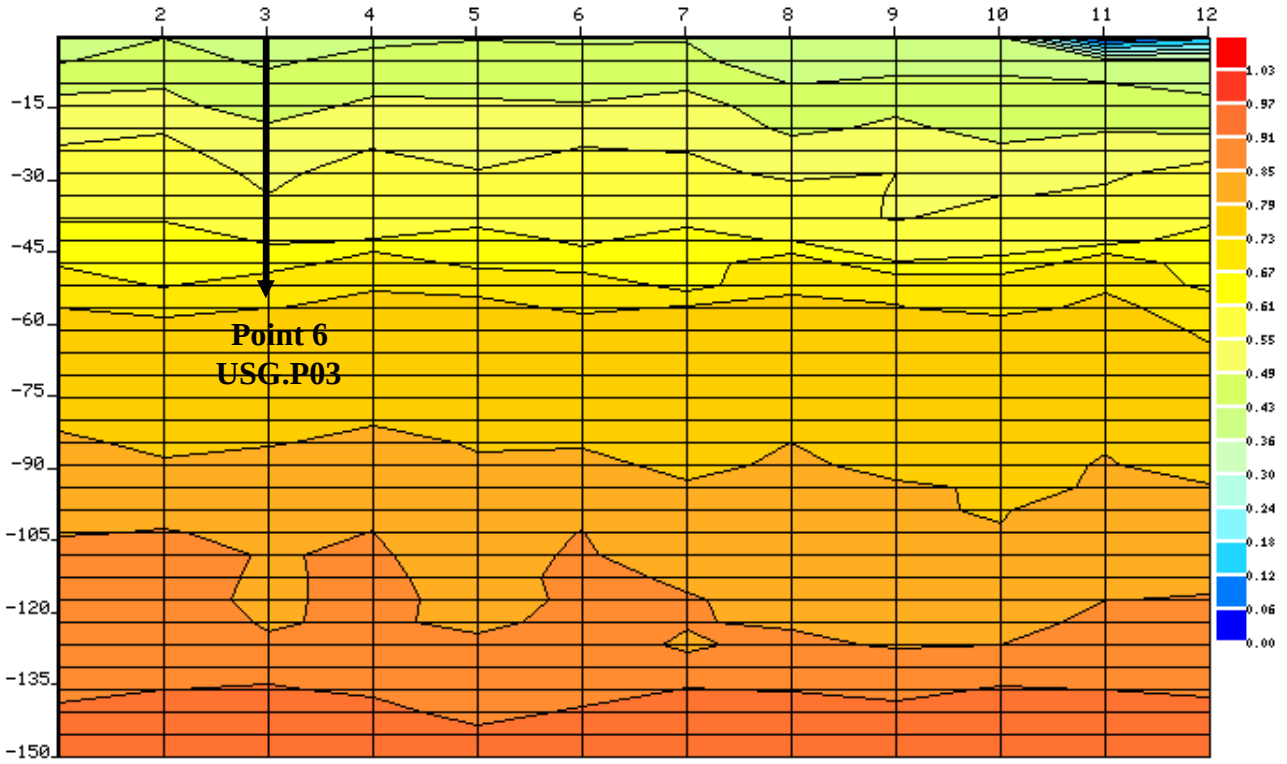
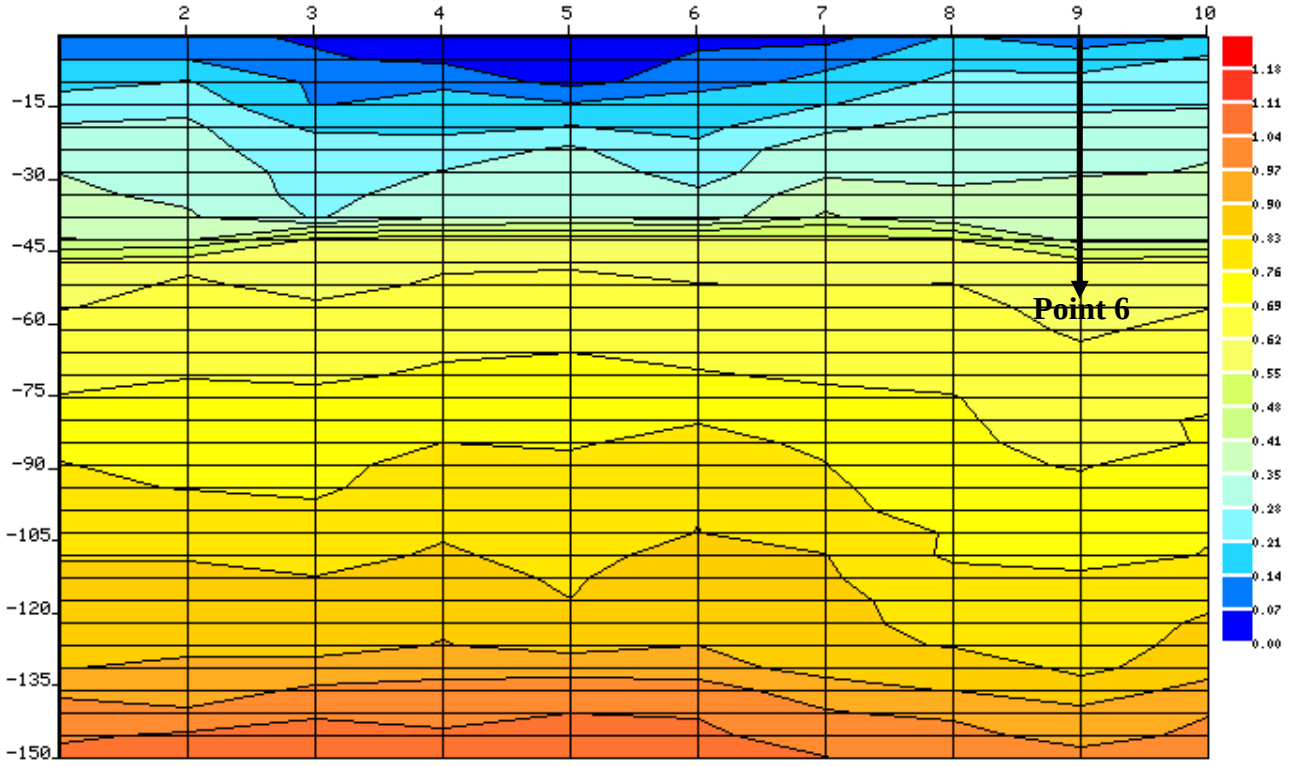
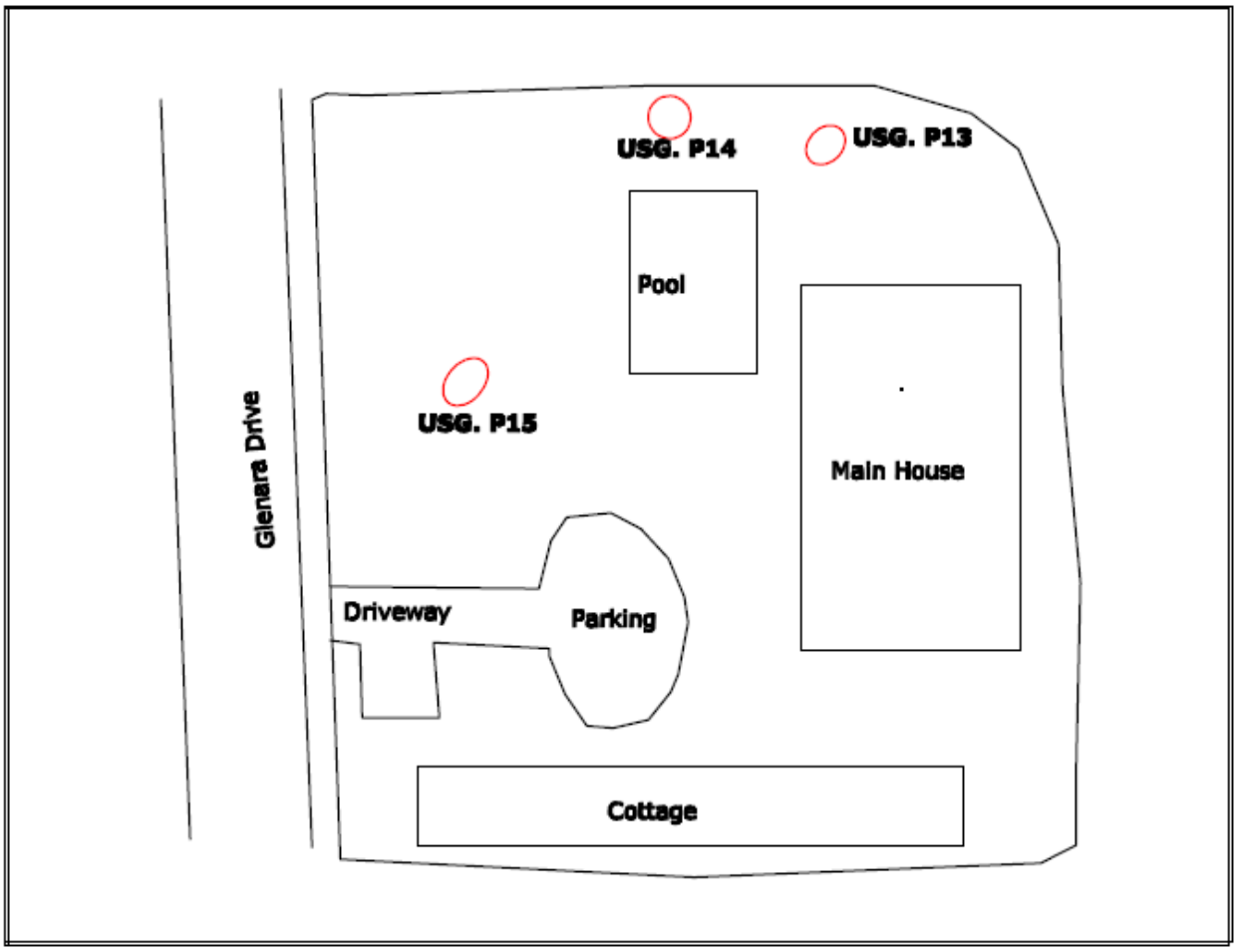


Survey line 5



Site Plan (Survey Pegs and Reference points)



Discussion and Recommendations

On the above profile survey lines, a fairly uniform ground formation across the whole area is noted, showing generally low earth resistivity results from 0 to 30m. Moderately high from 25m to 60m and very high below 75m, signs indicating partial and marginal rock fracturing respectively.

Anomalies that normally represent water bearing streams were detected in the rock formation within 100m but more concentrated within the first 60m below the ground level evidenced by the presence of v- shaped and slight horizontal contour lines representing rock fracturing, clearly seen on survey line 3 peg USG.P13 & USG.P14.

Several survey lines were carried out at one meter interval, results showed that resistivity increases with depth and minimal fracturing withing the lithologies underneath implying.

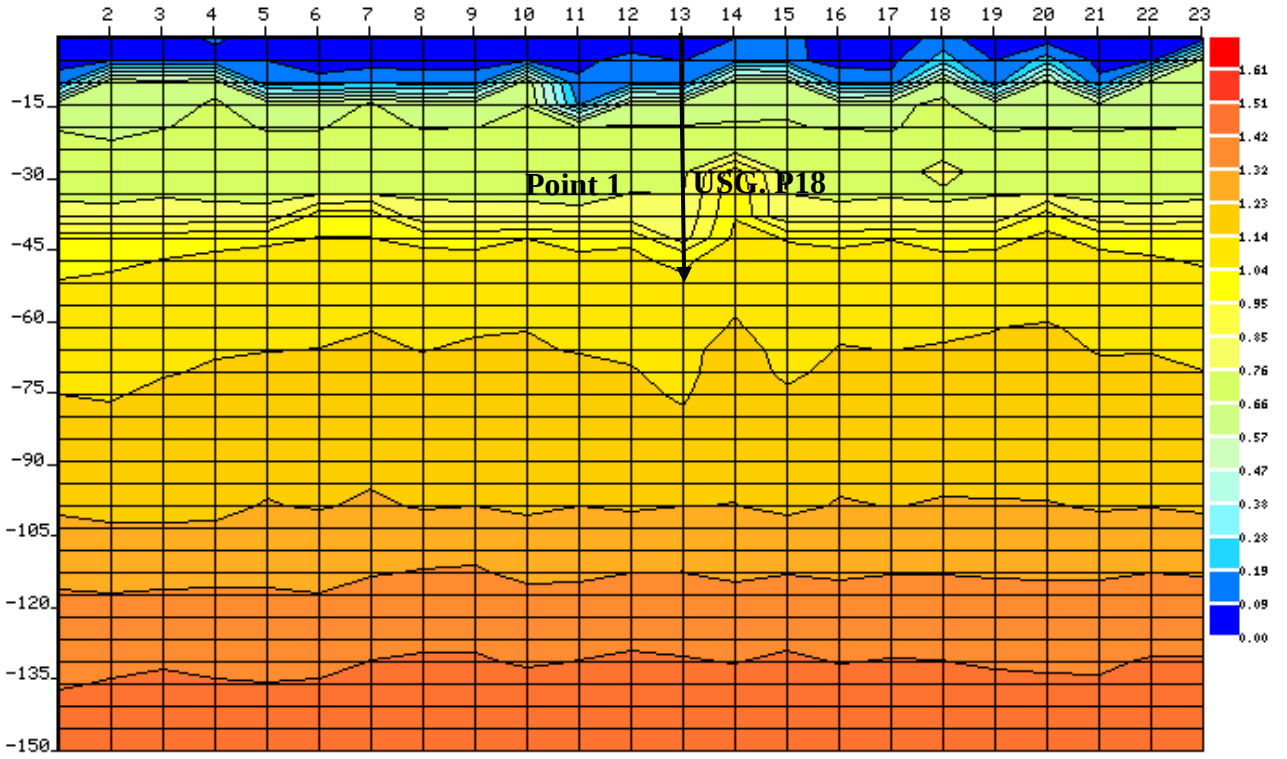
Point number four, marked Peg USG.P13 on survey line 3, extended to greater depths with the lowest resistivity values and this is an indication/ possibility of the existence of a more weathered and porous rock type and/or a network of cracks and joints that allow ground water to flow. Such readings therefore represent both surface and sub-surface potential and normally result in high yielding boreholes. Hence, **point 4/Peg USG.P13** on **survey line 3** is the best point found during survey for drilling, followed by point 5/peg USG.P14 on survey line 3, then lastly point 6/peg USG.P15 on survey line 4.

Minimum and maximum recommended drilling depths are estimated at 80m and 150m respectively.

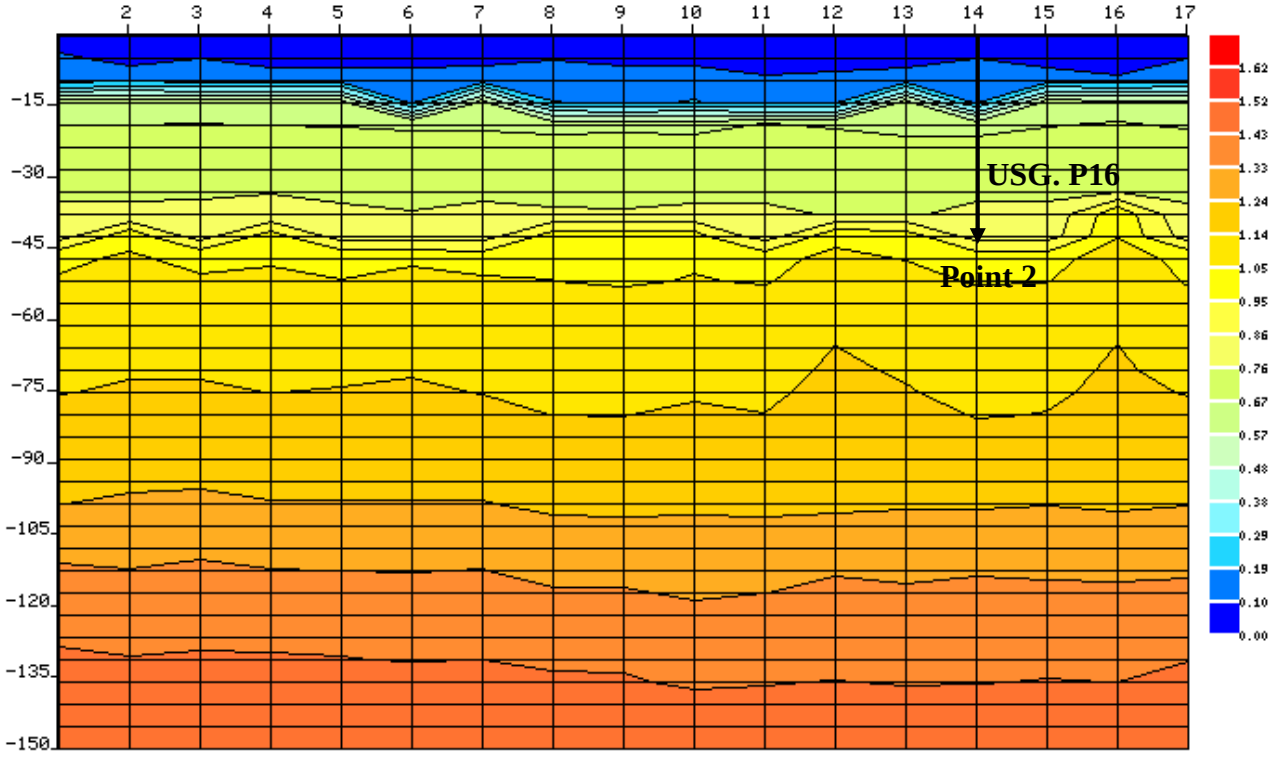
Drilling Order & Preference	Peg No.& Position	Interpretation	Estimated Minimum Depth of Drilling	Expected yield per hour
USG. P13	USG. P13 Site 4	Fracture	80m	±0.42m³
USG. P14	USG. P14 Site 5	Fracture	90m	±0.42m³
USG.P15	USG. P15 Site 6	Fracture	90m	±0.42m³

Site 6: 43 Kew Drive, Highlands, Harare

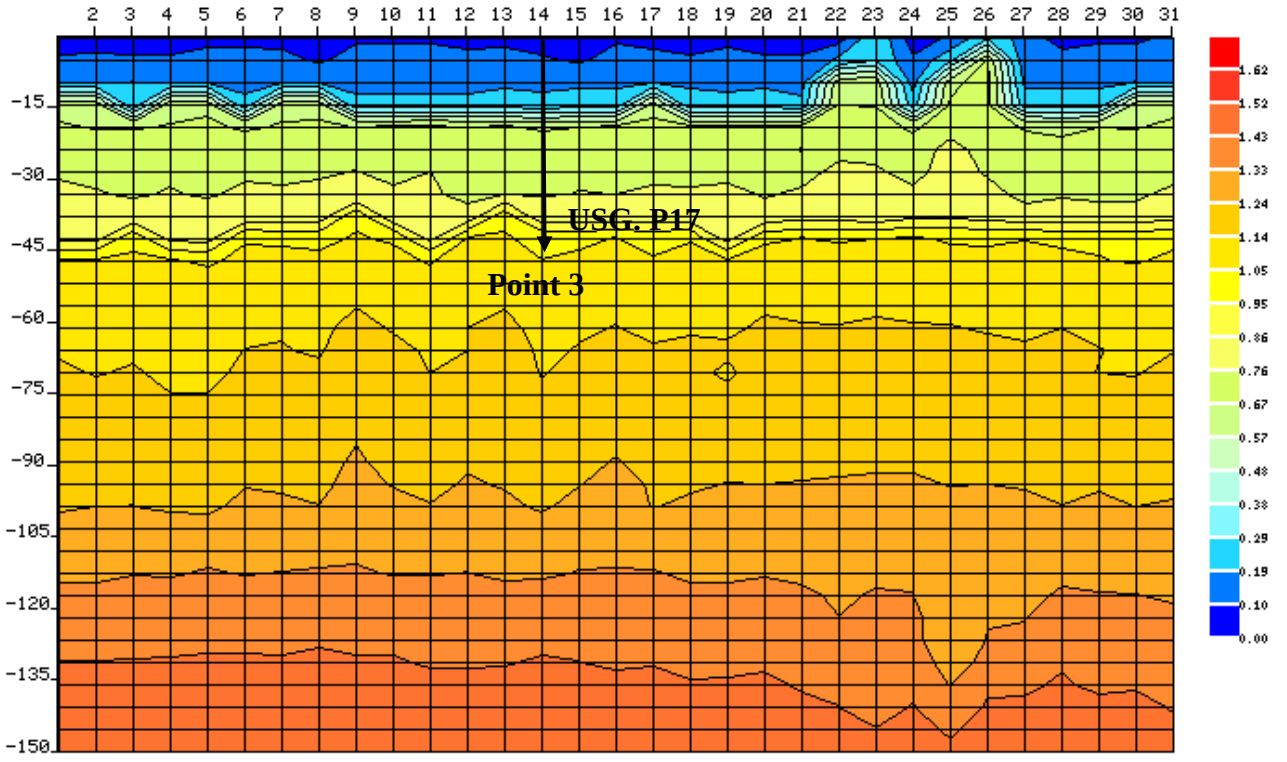
Survey line 1



Survey line 2

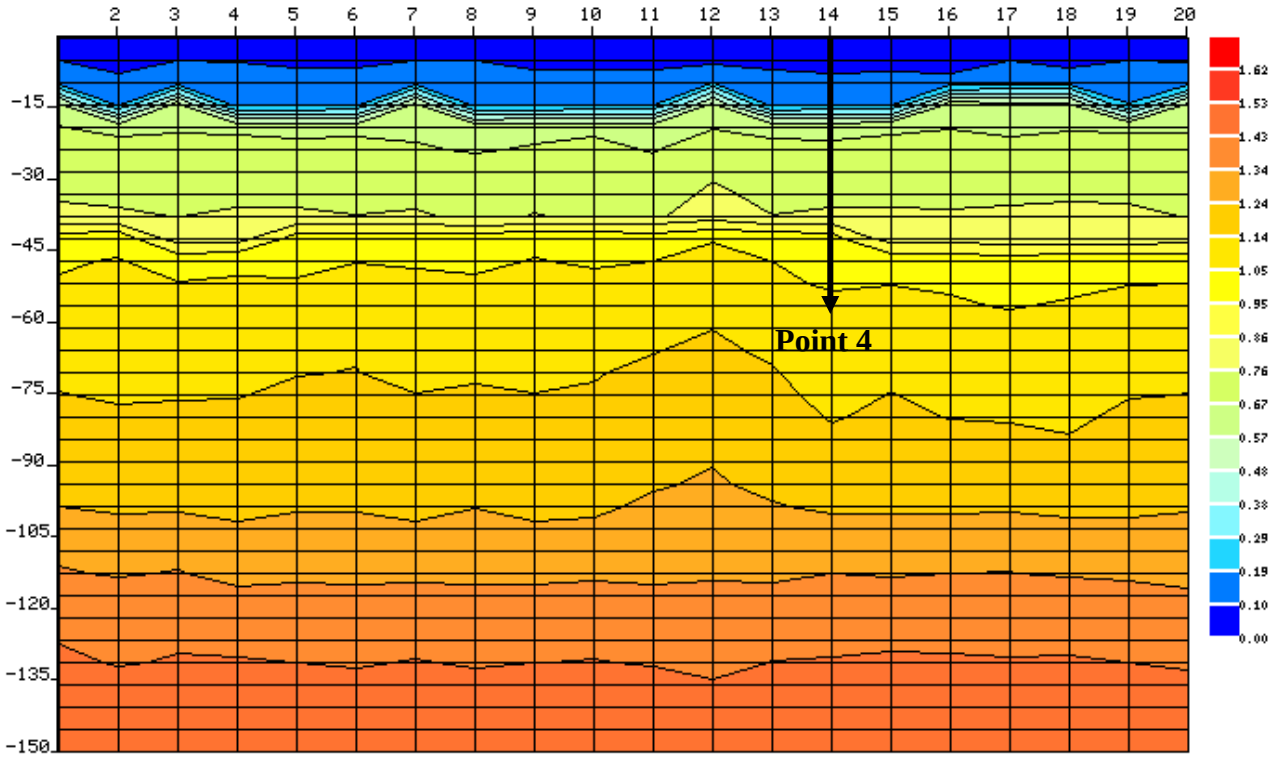


Survey line 3



Amanzi Oasis
104 Harare Drive, Harare
+263 772 696 989
+263 786 289 966
+263 779 660 794
sales@amanzioasis.com

Survey line 4



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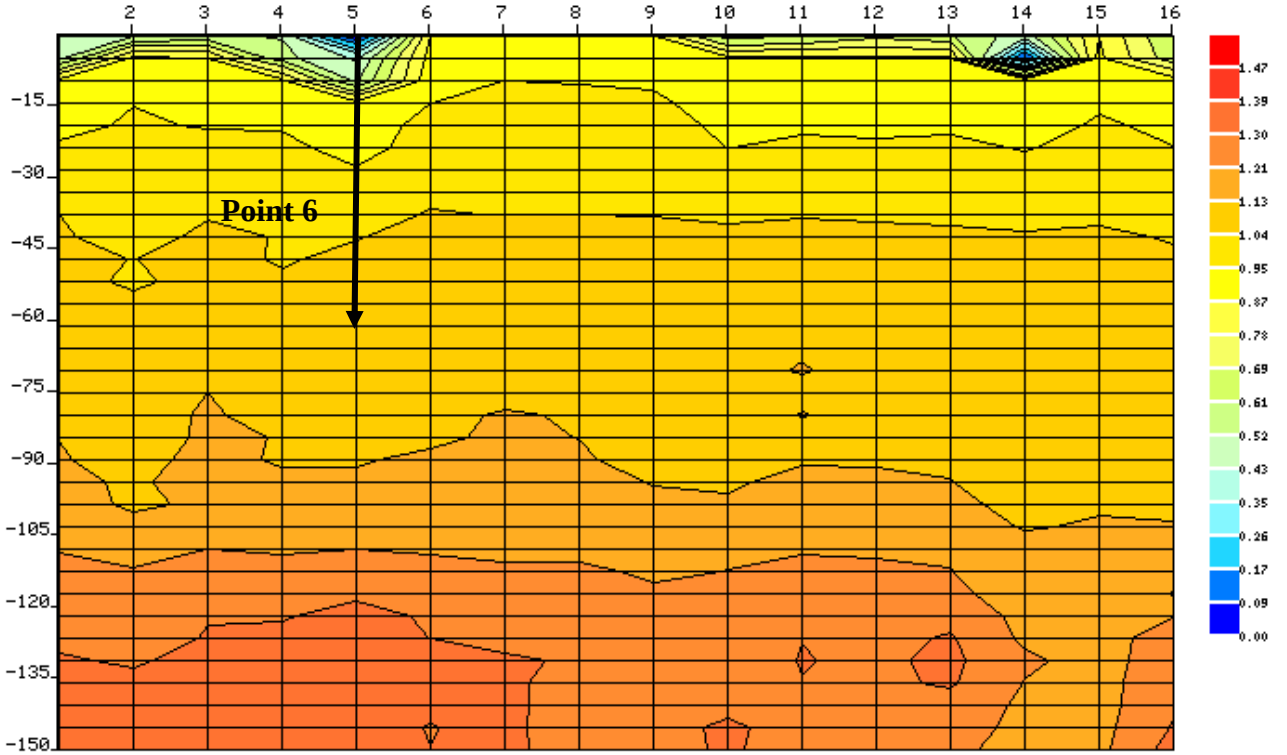
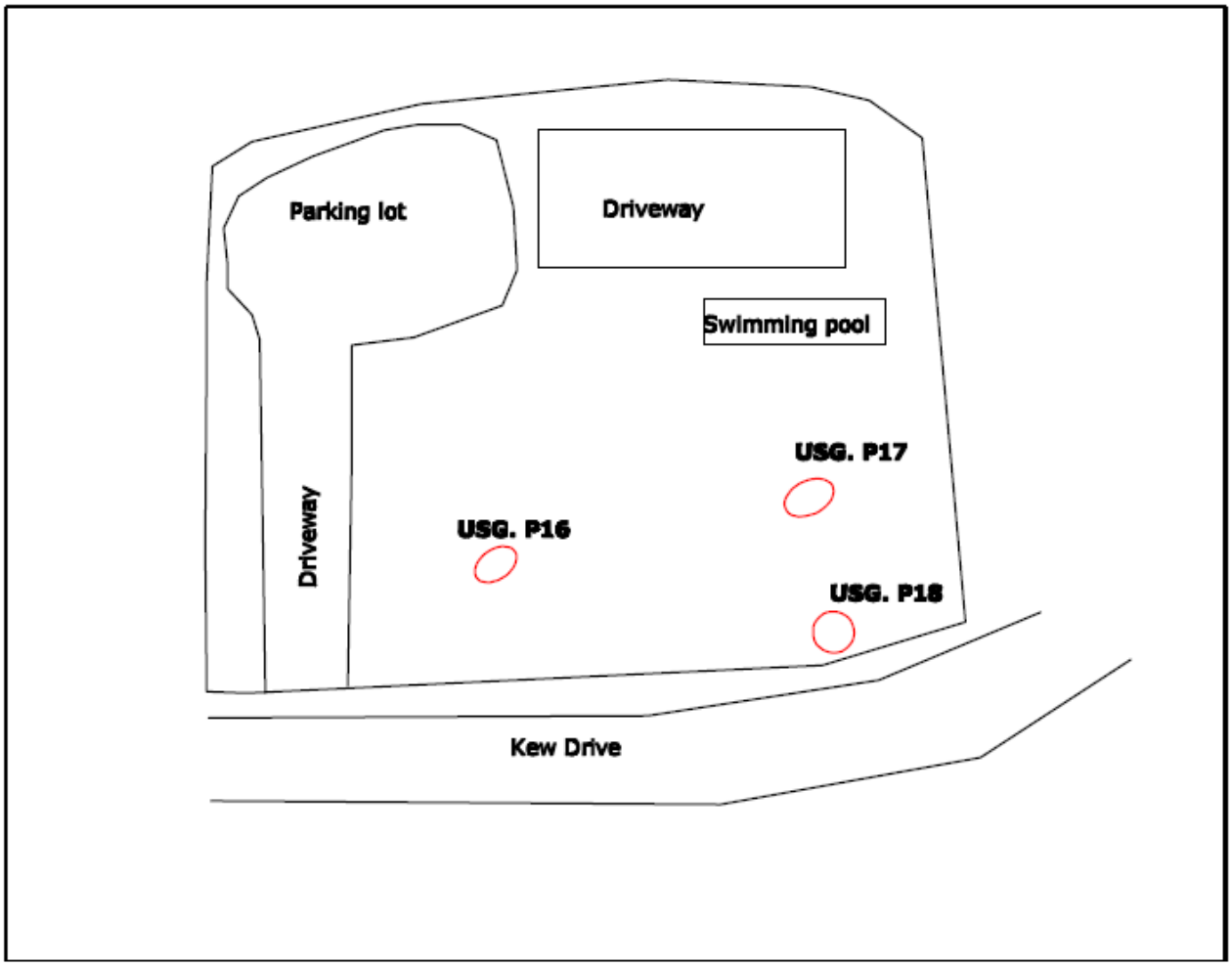
Survey line 5



Site Plan (Survey pegs and reference points)



Discussion and Recommendations

On the above profile survey lines, a fairly uniform ground formation across the whole area is noted, showing generally low earth resistivity results from 0 to 20m. Moderately high from 25m to 80m and very high below 85m, signs indicating partial and marginal rock fracturing respectively.

Anomalies that normally represent water bearing streams were detected in the rock formation within 100m but more concentrated within the first 60m below the ground level evidenced by the presence of v- shaped and slight horizontal contour lines representing rock fracturing, clearly seen on survey line 2 peg **USG. P16.**

Several survey lines were carried out at one meter interval, results showed that resistivity increases with depth and minimal fracturing withing the lithologies underneath implying.

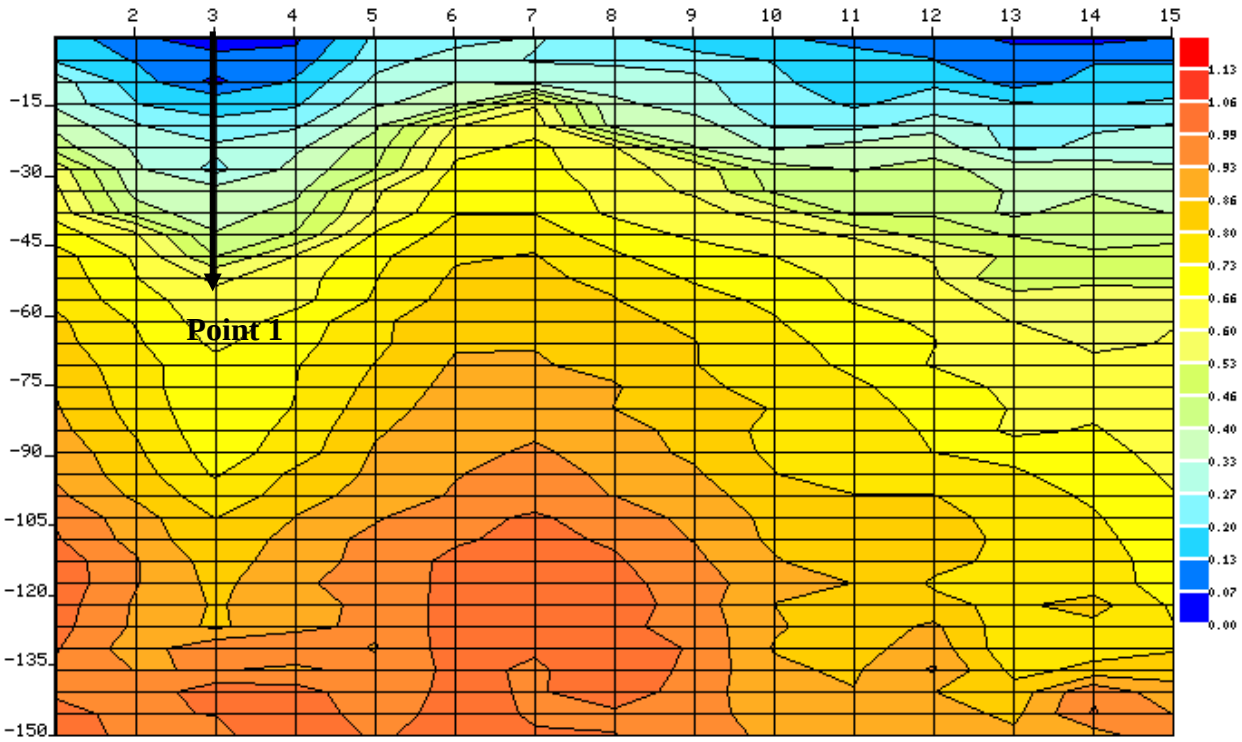
Point number two, marked Peg USG. P16 on survey line two, extended to greater depths with the lowest resistivity values and this is an indication/ possibility of the existence of a more weathered and porous rock type and/or a network of cracks and joints that allow ground water to flow. Such readings therefore represent both surface and sub-surface potential and normally result in high yielding boreholes. Hence, **point 2/Peg USG. P16** on **survey line 2** is the best point found during survey for drilling, followed by point 3/peg USG. P17 on survey line 3, then lastly point 1/peg USG. P18 on survey line 1.

Minimum and maximum recommended drilling depths are estimated at 80m and 130m respectively.

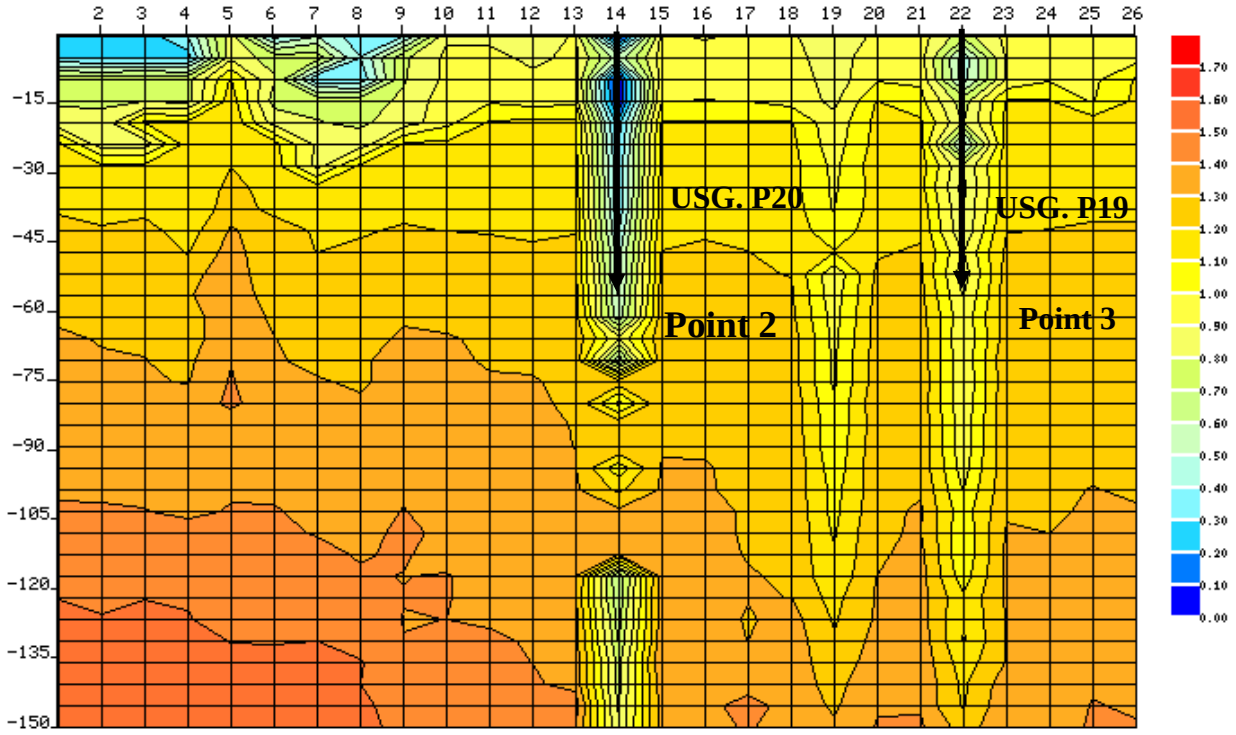
Drilling Order & Preference	Peg No.& Position	Interpretation	Estimated Minimum Depth of Drilling	Expected yield per hour
USG. P16	USG. P16 Site 2	Fracture	80m	±0.42m³
USG. P17	USG. P17 Site 3	Fracture	90m	±0.42m³
USG.P18	USG. P18 Site 1	Fracture	90m	±0.42m³

Site 7: 154 Arcturus Drive, Highlands, Harare

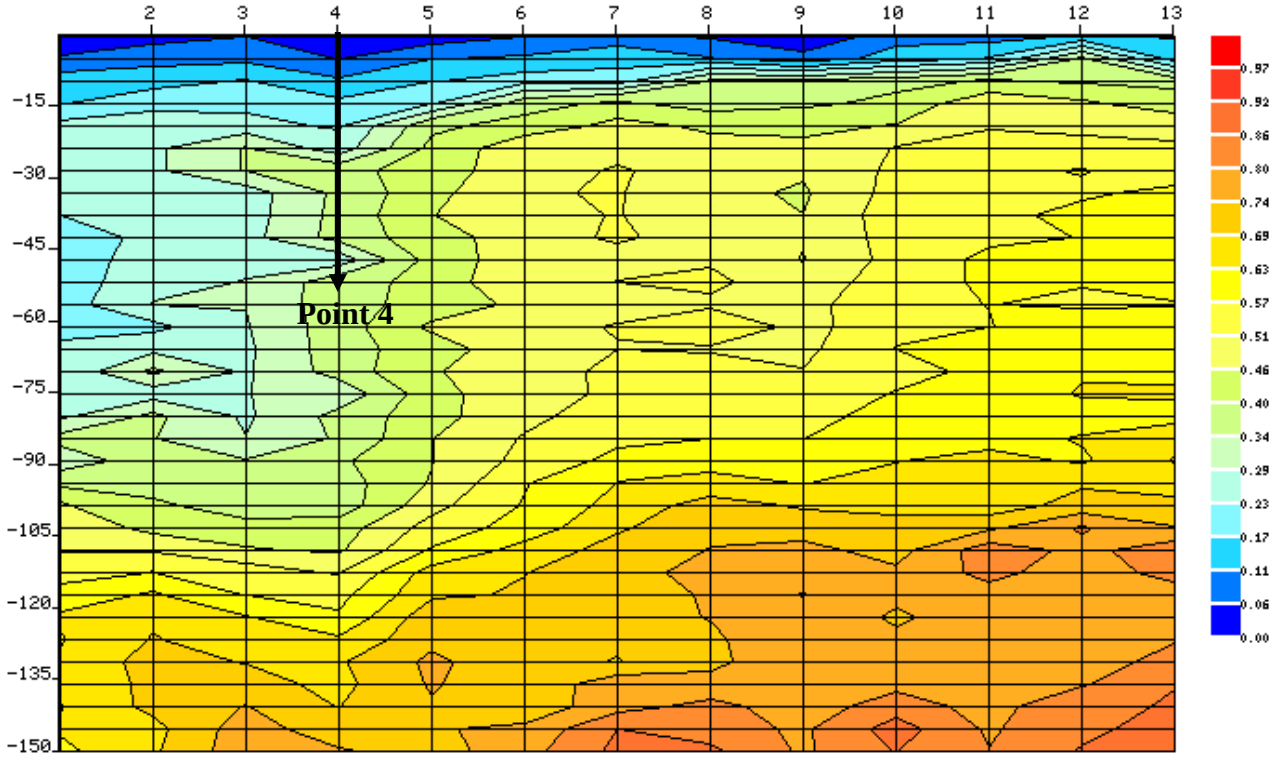
Survey Line 1



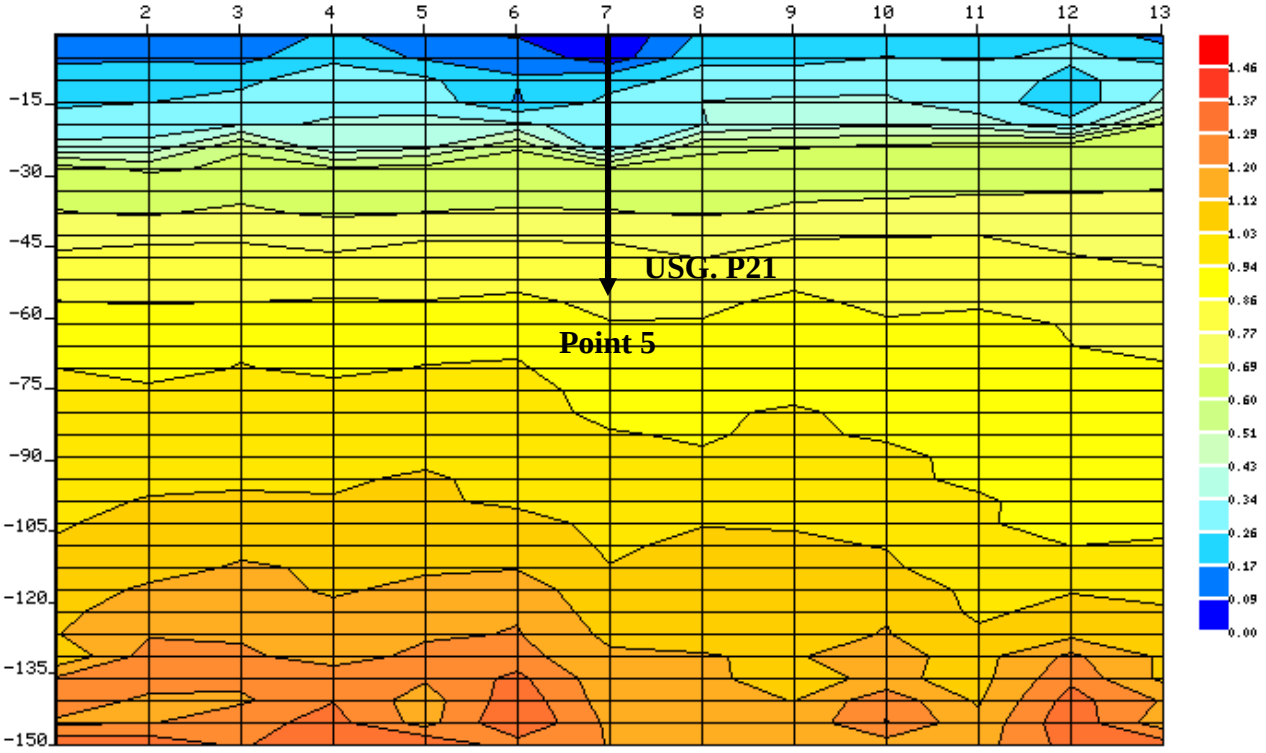
Survey Line 2



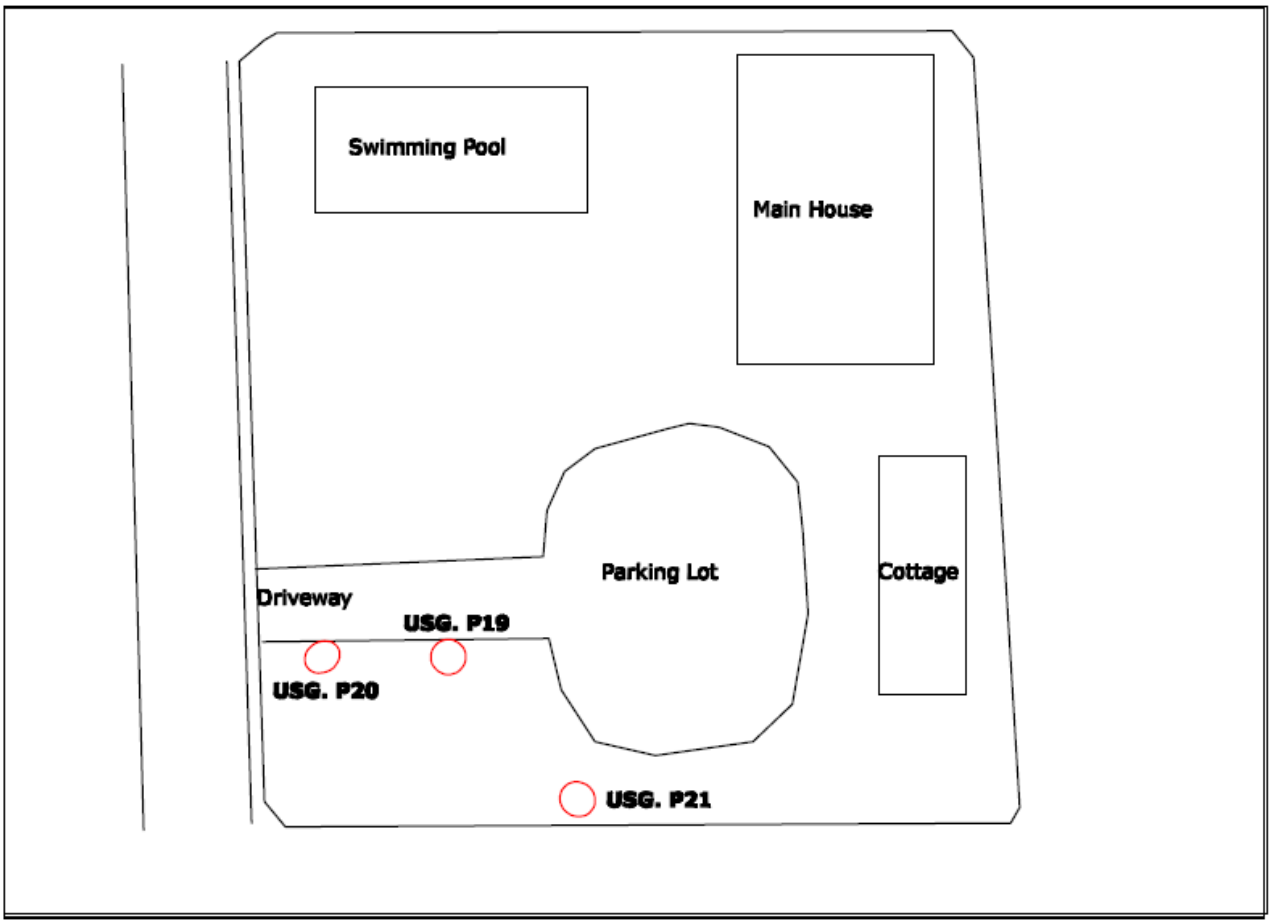
Survey line 3



Survey line 4



Site Plan (Survey pegs and Reference points)



Discussion and Recommendations

On the above profile survey lines, a fairly uniform lithological formation is noted throughout. Generally low resistivity values were obtained from 0-40m. Moderately high from 50m to 90m, however some points have low resistivity up to 100m.

Anomalies that normally represent water bearing streams were detected in the rock formation within 100m, but more concentrated within the first 70m. This is evidenced by the presence of v- shaped and slightly horizontal contour lines representing rock fracturing, clearly seen on survey line 2 peg **USG. P19.**

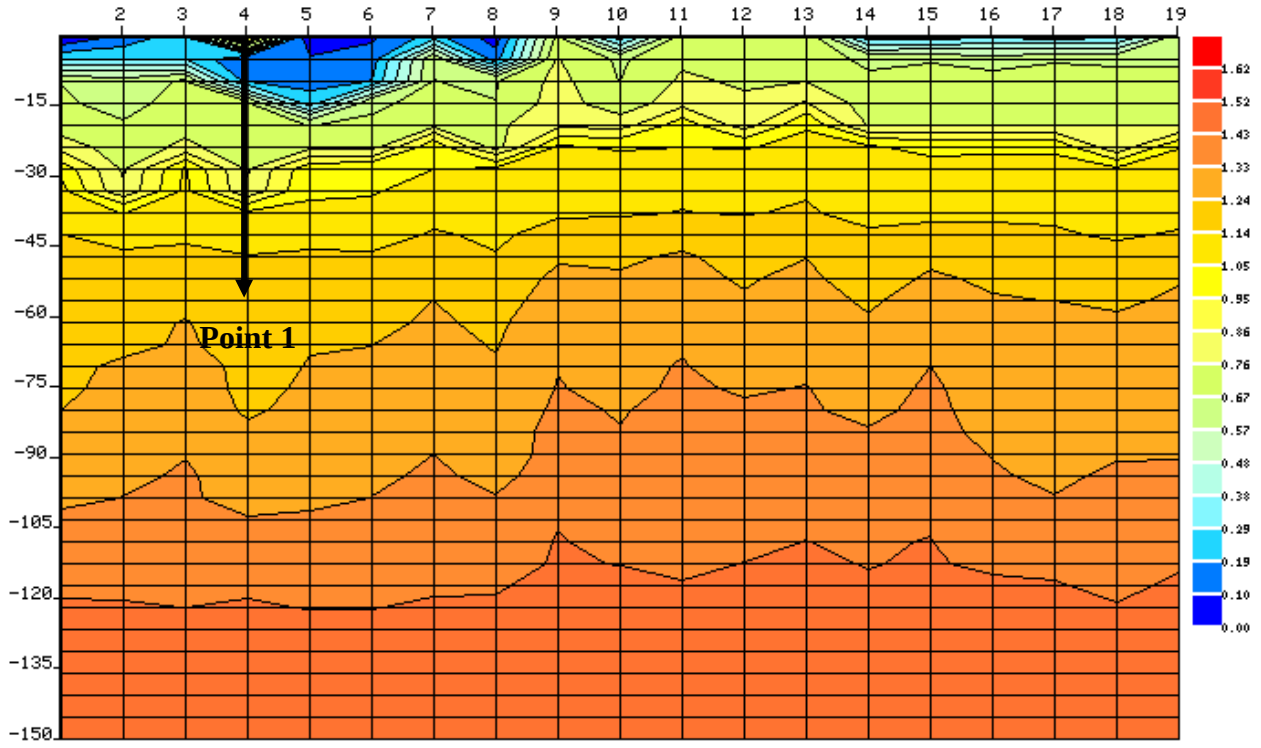
Point number three, marked peg USG. P19 on survey line 2, extended to a greater depth with the lowest resistivity values and this is an indication / possibility of the of a more weathered and porous rock type and /or a network of cracks and joints that allow groundwater to flow. Such readings therefore represent both surface and sub-surface potential and normally result in high yielding boreholes. Hence, **point 3/peg USG. P19** on survey **line 2** is the best point found during survey for drilling, followed by point 2 /peg USG. P20 survey line 2 and then lastly point 5 / peg USG. P21 survey line 4.

Minimum and maximum recommended drilling depths are estimated at 80m and 150m respectively.

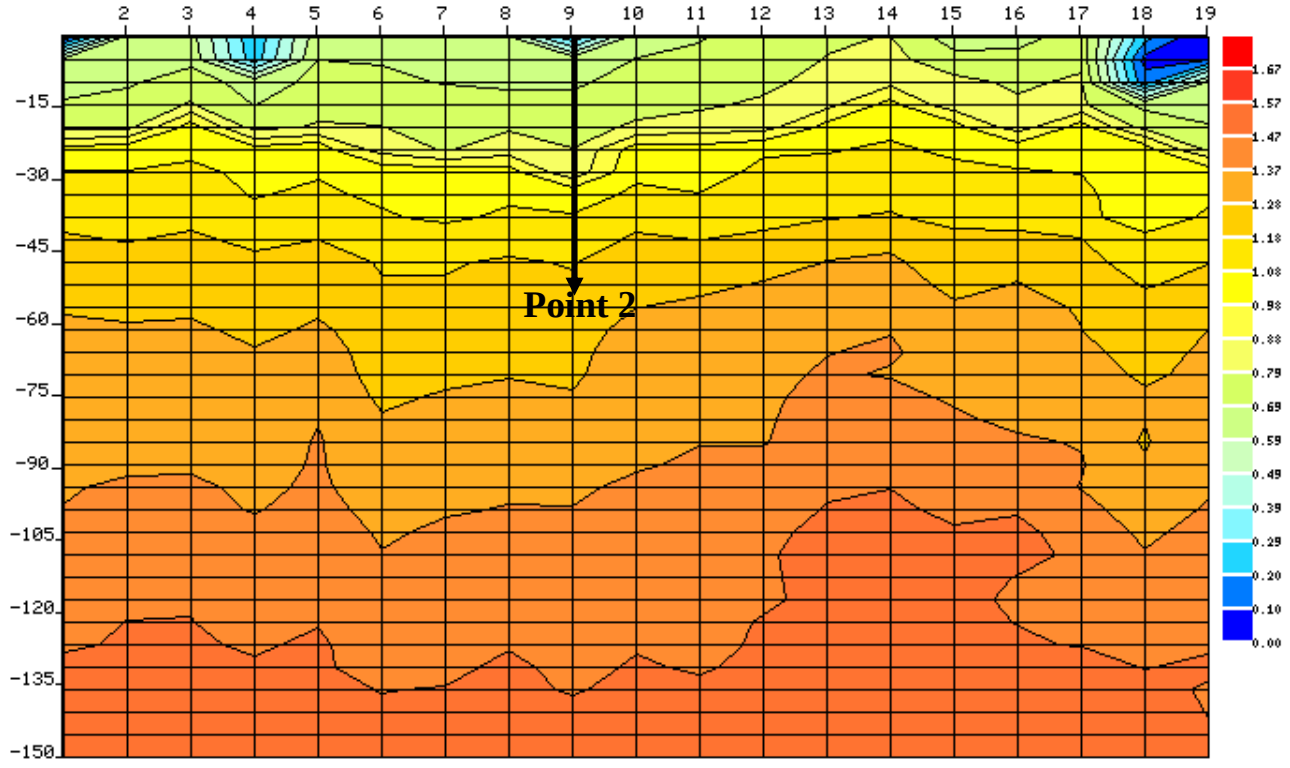
Drilling Order & Preference	Peg No.& Position	Interpretation	Estimated Minimum Depth of Drilling	Expected yield per hour
USG. P19	USG. P19 Site 3	Fracture	80m	±0.63m³
USG. P20	USG. P20 Site 2	Fracture	75m	±0.63m³
USG.P21	USG. P21 Site 5	Fracture	100m	±0.63m³

Site 8: 3 Tina Close, Chisipiti, Harare

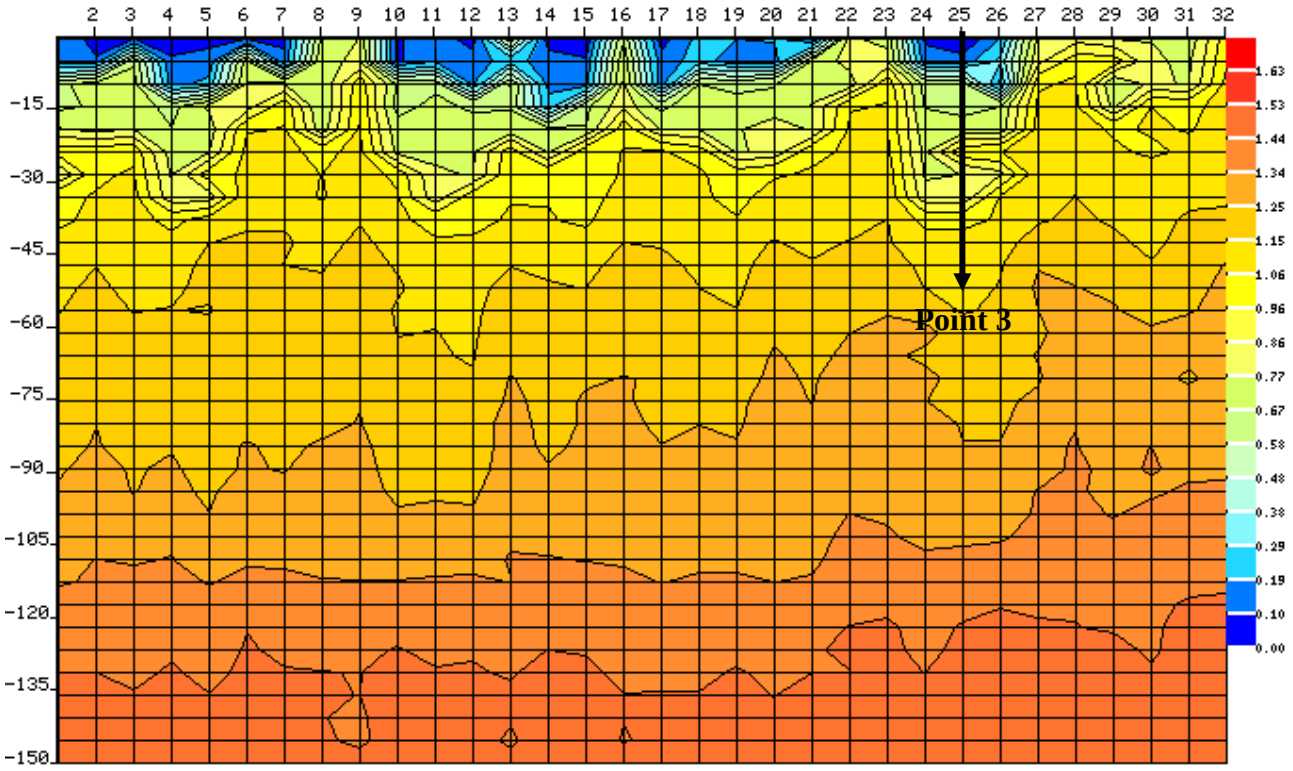
Survey Line 1



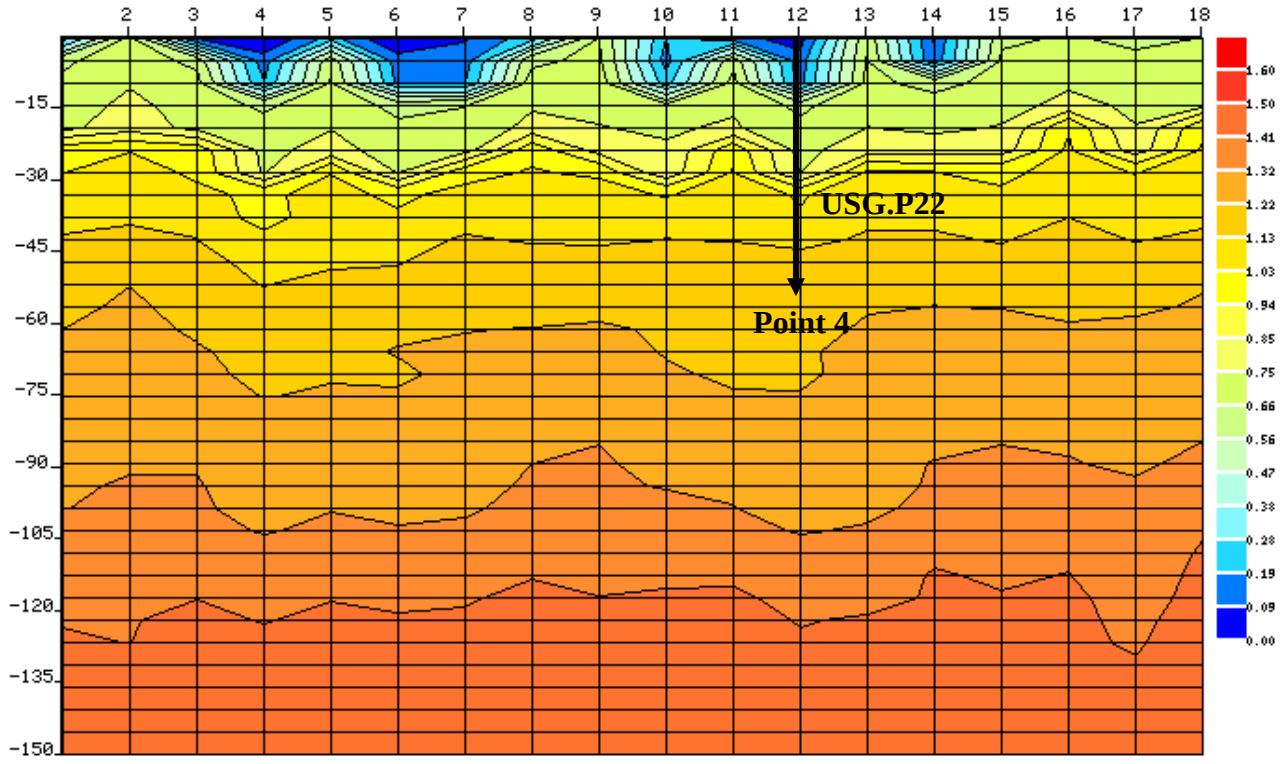
Survey Line 2



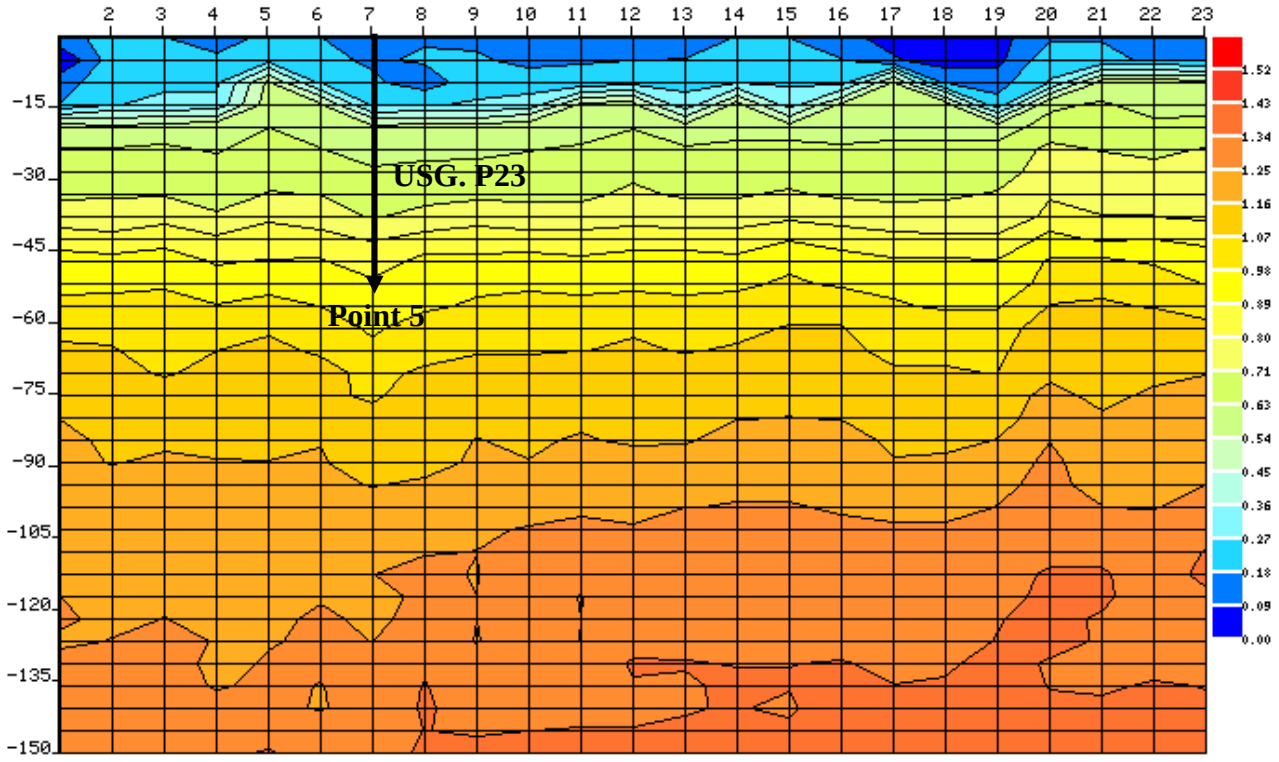
Survey line 3



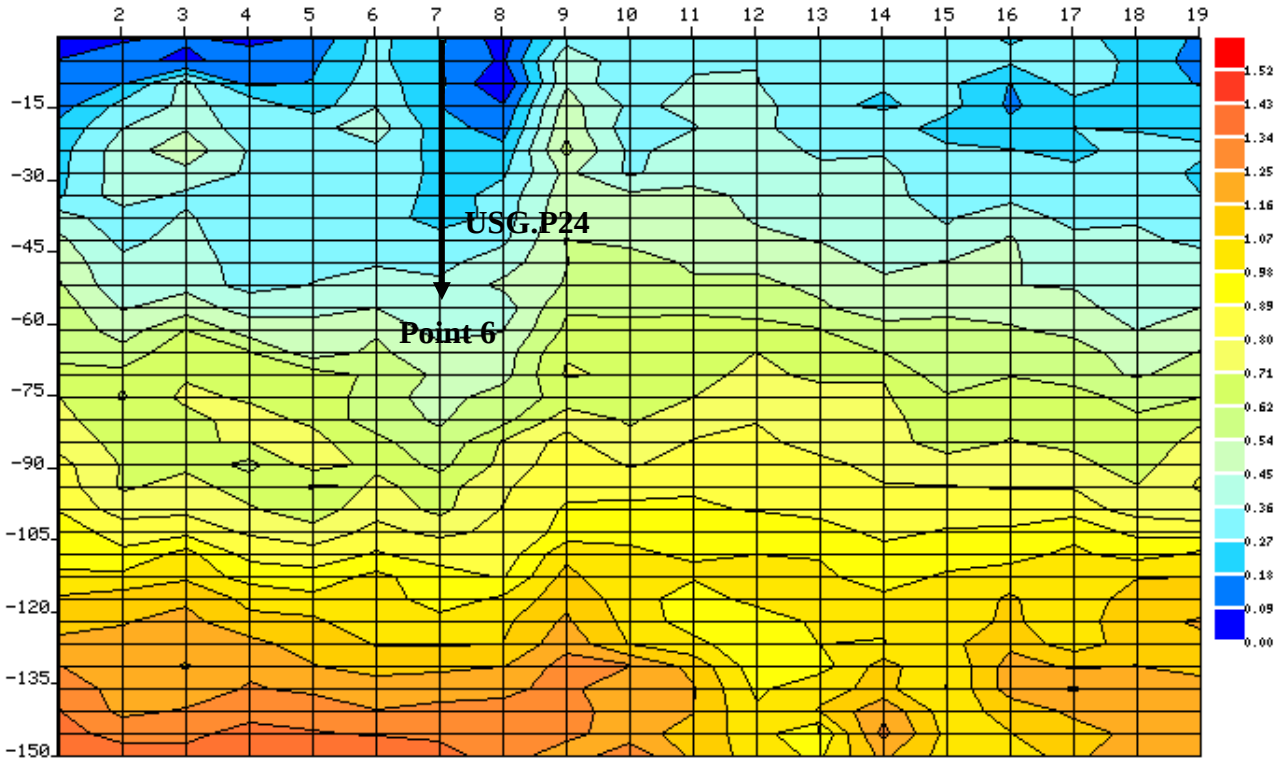
Survey line 4



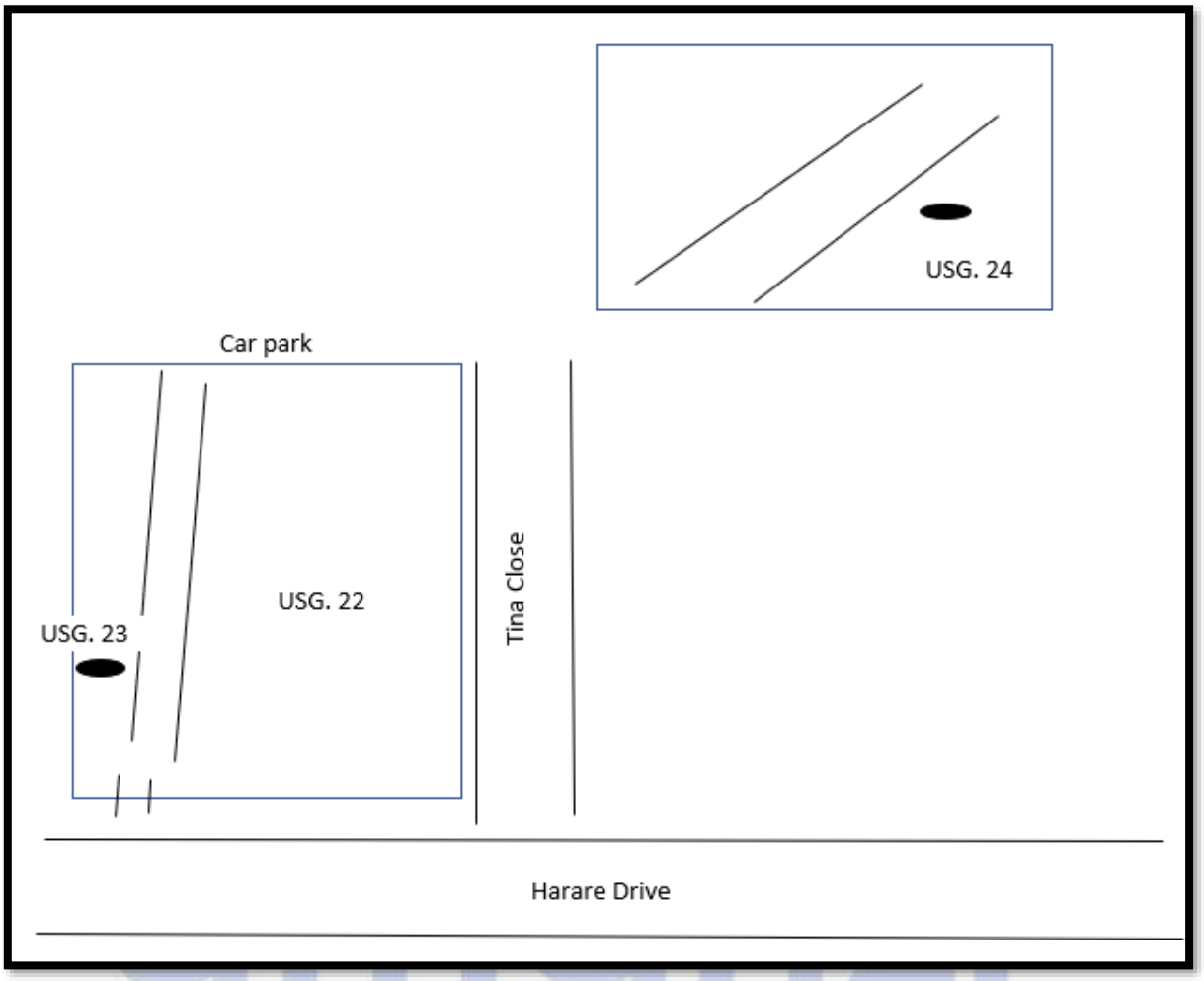
Survey line 5



Survey line 6



Site Plan (Survey Pegs and Reference Points)



Discussion and Recommendations

On the above profile survey lines, a fairly uniform ground formation across the whole area is noted, showing generally low earth resistivity results from 0 to 60m. Moderately high from 60m to 90m and very high below 95m, signs indicating partial and marginal rock fracturing respectively.

Anomalies that normally represent water bearing streams were detected in the rock formation within 120m but more concentrated within the first 60m below the ground level evidenced by the presence of v- shaped and slight horizontal contour lines representing rock fracturing, clearly seen on survey line 4 line 4.

Point number six, marked Peg USG.P24 on survey line 6, extended to greater depths with the lowest resistivity values and this is an indication/ possibility of the existence of a more weathered and porous rock type and/or a network of cracks and joints that allow ground water to flow. Such readings therefore represent both surface and sub-surface potential and normally result in high yielding boreholes. Hence, **point 6/Peg USG.P24** on **survey line 6** is the best point found during survey for drilling, followed by point 4/peg USG.P22 on survey line 4, then lastly point 5/peg USG.P23 on survey line 5.

Minimum and maximum recommended drilling depths are estimated at 70m and 140m respectively.

Drilling Order & Preference	Peg No.& Position	Interpretation	Estimated Minimum Depth of Drilling	Expected yield per hour
USG. P22	USG. P22 Site 4	Fracture	80m	±0.5m³
USG. P23	USG. P23 Site 5	Fracture	80m	±0.5m³
USG.P24	USG. P24 Site 6	Fracture	70m	±0.72m³

Amanzi Oasis Inc. advises the client to apply for Authority to Drill Permit at their closest Zinwa Sub-Catchment offices. They are required to carry this siting report as proof that the survey has been carried out.

Amanzi Oasis Inc. wishes to advice the client that all opinions in this report are given in good and honest faith based on observations on the ground, and no guarantees can be given.